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PROPELLANT TEST RESULTS, LGM-30 STAGE III, DISSECTED MOTOR PROGRAM

Elizabeth M. Dalaba

Ogden Air Logistics Center
Hill Air Force Base, Utah

October 1974

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13 ABSTRACT

This report contains results of propellant testing of LGM-30 Stage III dissected motors. Testing was accomplished in accordance with General Test Directive 3 and MME 74NE102.

Data from this test period and from previous test periods have been combined and included in regression analyses. Motors 0031064, 0031134, 0032434, 0033174 and Grain 131 have been combined in composite regressions. In general, data are in agreement with past data. Shore A hardness is an exception.

There are some statistically significant trends which are not of immediate concern.

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LGM-30 3RD STAGE

DISSECTED MOTOR PROGRAM

PROPELLANT TEST RESULTS

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RELATED DOCUMENTS

Hercules Incorporated Documents

MTO-201-9, 20 April 1965

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203(71), January 1971

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Management Document,

March 1972

GLOSSARY OF ABBREVIATIONS AND TERMS

Aging Trend	A change in properties or performance resulting from aging of material or component
ATR	Attentuated Total Reflectance
Degradation	Gradual deterioration of properties or performance
DTA	Differential Thermal Analysis
E	Modulus (psi), defined as ratio of nominal stress to corresponding nominal strain
e_m	Strain at maximum stress (in/in)
e_r	Strain at rupture (in/in)
E(t)	Stress Relaxation Modulus
Failure Criterion	Defined as measureable performance parameter or material property limit which if exceeded will cause the motor to fail to perform within model specification requirements.
"F" ratio	The ratio of the variance accounted for by the regression function to the random unexplained variance. The regression function having the most significant "F" ratio is used for plotting data. The ratio is also used in detecting significant changes in random variation between succeeding time points.
MANCP	Propellant Laboratory Section, Directorate of Maintenance, Ogden Air Logistics Center
MMEMP	Propulsion Engineering Section, Mechanical and Aero Engineering Branch, Directorate of Materiel Management, Ogden ALC
Regression Equation	The general form of the regression equation is $Y = a + bx$, where x = value of the independent variable in months.
Regression Line	Line representing mean test values with respect to time
SAMSO	Space and Missile Systems Organization, Air Force Systems Command

GLOSSARY OF ABBREVIATIONS AND TERMS (Cont)

S_b	Standard error of estimate of the regression coefficient
S_e or $S_{Y.X}$	Standard deviation of the data about the regression line
S_m	Maximum stress (psi)
S_r	Stress at rupture (psi)
Standard Deviation (S_y)	Square root of variance
"t" test	A statistical test used to detect significant differences between a measured parameter and an expected value of the parameter (Determines if regression slope differs from zero at the 95% confidence level)
TCLE	Thermal Coefficient of Linear Expansion
TGA	Thermogravimetric Analysis
TRW	TRW Systems
Variance	The sum of squares of deviations of the test results from the mean of the series after division by one less than the total number of test results

SECTION I

INTRODUCTION

A. PURPOSE:

The purpose of testing was to determine the effects of aging on LGM-30 Stage III Dissected Motors in support of service life estimates by MMEMP. Secondary aging effects, if any, were to be determined. Work was performed in accordance with General Test Directive GTD-3C.

B. BACKGROUND

Testing of propellant from dissected grains (Grains 131, 216 and 336) was a part of the component program. In 1968 ten dissected motors were secured and a separate testing program was designed to complement the surveillance testing (ATP) of block propellant. Additional motors and Grain 70 were added to a revised program. In 1973 three motors 0031064, 031134 and 0032434 were further dissected by Hercules.

Current testing of dissected motors is limited to five motors per year. Motor numbers 0031064, 0031134 and 0032434 will be tested each year together with Grain 131. Grain 70 will be tested in even numbered years and motor number 0033174 will be tested in odd numbered years.

The test program is shown in Table 1-1. Motor cast dates and powder lot numbers for all motors are shown in Table 1-2.

TABLE 1-1

THIRD STAGE PROPELLANT PROGRAM

Test	Configuration	Test Conditions
Low Rate Tensile	1/4" JANNAF Dogbone	77°F, 2.0 in/min
Failure Envelope	1/4" JANNAF Dogbones	-30, -10, 20, 77, and 130°F .02, 0.2, 2, and 20 in/min
Very Low Rate Tensile	1/4" JANNAF Dogbone	77°F, 2×10^{-4} in/min 50% RH
Low Rate Biaxial	3/4" GL Rail, 3/16" thick	77°F, 0.2 in/min
High Rate Triaxial	3/4" GL Rail, 3/16" thick	77°F, 300 psi N_2 1000 in/in/min
High Rate Tensile	3/4" GL Dogbones 1/2" thick	77°F, 1000 in/in/min
High Rate Hydrostatic	3/4" GL Dogbones 1/2" thick	77°F, 1000 in/in/min 300 psi
Stress Relaxation	1/2" x 1/2" x 4" EB	77°F, 3%
Hardness	1/4" JANNAF Dogbone ends	Shore A & C 10 sec
DTA	.040" wafers	12°C rise/min
TGA	.040" wafers	9°C rise to ign 12°C rise to 140° hold for 50 min
Burning Rate	.156 x .156" x 5"	500 psig
Heat of Explosion	1/2" x 3/8" x 2"	77°F, N_2 pressure
TCLE	0.200" wafer	5°C rise/min -100°C to + 80°C

TABLE 1-1 (Cont)

THIRD STAGE PROPELLANT PROGRAM

Test	Configuration	Test Conditions
Case Bond Tensile	1.128" dia milled from 1 1/2" block	CHS 0.1 in/min
Case Bond Peel	1 block 3" wide cut in 3 strips	CHS 5 in/min
ATR	.118 x .709 x 2.008"	

TABLE 1-2

MOTOR CAST DATES

Motor Nr	Powder Lot	Cast Date
Grain 79	SR-47-60	Jun 60
Grain 131	SR-69A-60	21 Jan 61
00 31036	SR-100-61	3 Oct 62
00 31057	SR-68-62	23 Oct 62
00 31064	SR-56-62	21 Oct 62
00 31097	SR-68-62	8 Dec 62
00 31134	SR-68-62	28 Jan 63
00 31136	SR-68-62	2 Feb 63
00 31158	SR-68-62	20 Feb 63
00 32248	SR-58-63	28 Aug 63
00 32107	SR-28-63	19 May 63
00 32116	SR-28-63	17 May 63
00 32133	SR-51-63	10 Jun 63
00 32137	SR-51-63	13 Jun 63
00 32140	SR-28-63	29 Apr 63
00 32434	RAD-1-1-63	21 Jan 64
00 32831	RAD-1-8-65	29 Jun 65
00 33174	RAD-1-10-66	20 Jan 67

SECTION II

SUMMARY AND EVALUATION OF TEST RESULTS

Test results are summarized by the significance of the "t" test in Table 2-1. Using the regression line, the coefficient of variation at 10 years has been determined for several tests, and this data is summarized in Table 2-2. Strain at maximum has been determined for individual motors.

There are noticeable discrepancies when the significance of the slope is examined particularly for uniaxial tensile at 2 in/min. Although the combined data shows a significant increase in strain, motors 0031064 and 0033174 show a significant decrease. Other tensile tests (very low rate biaxial and high rate triaxial) show an increase in strain for the composite regression. Decreases for individual motors are not significant.

Table 2-2 shows clearly the differences in the powder lots. Strain at maximum stress is higher for Sunflower lots than for Radford, and in general Gr 131 falls between the average of the other values.

Relaxation modulus shows a significant increase not only for the composite regression but for individual motors as well.

Shore A hardness composite regression shows a significant decrease. The shift in trend has resulted from the 1973 values

which are lower than for any previous test period. Shore C hardness shows a significant increase.

Storage shear modulus continues to show a decrease while loss tangent shows a significant increase.

Case bond tensile shows a significant increase in strength. Although the average peel strength of the composite shows a significant decrease only motor 0032434 shows this trend.

Despite some inconsistencies in the data in some tests, there does not appear to be any trend of immediate concern.

TABLE 2-1

SUMMARY OF TEST RESULTS

*Significance of "t" Test

Test/Parameter	5 Mtr	31064	31134	32434	33174	Gr 131
Low Rate Tensile (2 in/min)						
em	sig +	sig -	sig +	N/S -	sig -	sig +
Sm	sig +					
er	N/S +					
Sr	sig +					
E	sig +					
Very Low Rate Tensile (.0002 in/min)						
em	N/S +	sig +	N/S +	N/S -	N/S -	N/S -
Sm	sig -					
er	N/S -					
Sr	sig -					
E	sig +					
Biaxial Tensile (0.2 in/min)						
em	sig +	sig +	N/S +	sig +	N/S +	N/S -
Sm	N/S +					
er	sig +					
Sr	N/S +					
E	sig -					
High Rate Triaxial (1750 in/min, 300 psi)						
em	sig +	N/S +	N/S +	sig +	sig +	N/S +
Sm	N/S +					
er	sig +					
Sr	sig +					
E	N/S -					

TABLE 2-1 (cont)

Test/Parameter	5 Mtr	31064	31134	32434	33174	Gr 131
Relaxation Modulus (3% Strain)						
10 sec	sig +	sig +	sig +	sig +	sig +	
50 sec	sig +					
100 sec	sig +					
1000 sec	sig +	sig +	sig +	sig +	sig +	
Hardness						
Shore A	sig -					
Shore C	sig +					
Case Bonds						
Tensile	sig +	N/S +	sig +	sig +	sig -	sig +
Av Peel	sig -	N/S -	N/S +	sig -	N/S +	sig +
Dynamic Response						
Shear Modulus						
200 Hz	N/S -					
600 Hz	Sig -					
Loss Tangent						
200 Hz	sig +					
600 Hz	sig +					

* N/S = Not Significant
  sig = Significant

TABLE 2-2

Coefficient of Variation at 10 Years

Parameter		Crosshead Rate	Figure Nr	N	$\bar{x}$ 10 yrs	Se	Se/ $\bar{x}$ x 100	Y Intercept
Uniaxial,	em	2 in/min	4-1	194	0.433	0.030	6.9	0.389
	Sm		4-2	194	434.	42.9	9.9	334.4
	er		4-3	194	0.487	0.03	6.2	0.483
	E		4-5	194	1770.	269.0	15.2	1533.
0031064	em		4-6	50	0.446	0.012	2.7	0.482
0031134	em		4-7	49	0.456	0.013	2.8	0.387
0032434	em		4-8	50	0.382	0.015	3.9	0.389
0033174	em		4-9	20	0.379	0.013	3.4	0.443
00GR131	em		4-10	25	0.420	0.014	3.3	0.388
Uniaxial,	em	$2x10^{-4}$in/min	5-1	133	0.29	0.047	16.2	0.264
	Sm		5-2	133	70.8	8.8	12.4	82.
	er		5-3	133	0.323	0.043	13.3	0.323
	E		5-5	133	588.	94.5	16.1	407.0
0031064	em		5-6	31	0.318	0.054	17.0	0.159
0031134	em		5-7	31	0.307	0.050	16.1	0.250
0032434	em		5-8	31	0.248	0.024	9.7	0.278
0033174	em		5-9	15	0.254	0.040	15.7	0.365
00GR131	em		5-10	25	0.278	0.025	9.0	0.310

TABLE 2-4 (cont)

Parameter	Crosshead Rate	Figure Nr	N	$\bar{x}$ 10 yrs	Se	Se/ $\bar{x}$ x 100	Y Intercept
Biaxial, em	0.2 in/min	6-1	62	0.288	0.022	7.8	0.234
Sm		6-2	62	284.	24.2	8.5	271.4
er		6-3	62	0.332	0.027	8.1	0.284
E		6-5	62	1396.	218.1	15.6	1785.8
0031064 em		6-6	17	0.292	0.009	3.0	0.262
0031134 em		6-7	17	0.286	0.019	6.6	0.281
0032424 em		6-8	17	0.243	0.010	4.1	0.196
0033174 em		6-9	4	0.328	0.017	5.2	0.174
00GR131 em		6-10	7	0.279	0.026	9.3	0.313
Triaxial,em	1750 in/min 300 psi	7-1	81	0.253	0.029	11.5	0.248
Sm		7-2	81	1516.	82.8	5.5	1458.2
er		7-3	81	0.296	0.025	8.4	0.266
E		7-5	81	8550.	1457.7	17.0	9251.
0031064 em		7-6	19	0.290	0.024	8.3	0.284
0031134 em		7-7	20	0.289	0.017	5.9	0.261
0032434 em		7-8	19	0.282	0.028	9.9	0.223
0033174 em		7-9	9	0.382	0.042	11.0	0.079

TABLE 2-2 (cont)

Parameter	Crosshead Rate	Figure Nr	N	$\bar{x}$ 10 yrs	Se	Se/ $\bar{x}$ x 100	Y Intercept
Relaxation ER	10 Sec	8-1	135	1244.	138.8	11.1	1095.
Modulus (3%)	1000 Sec	8-4	135	746.	77.1	10.3	616.
0031064 ER	10 Sec	8-5	34	1235.	86.2	7.0	889.
	1000 Sec	8-6	34	748.	37.3	5.0	454.
0031134 ER	10 Sec	8-7	34	1292.	81.0	6.3	1032.
	1000 Sec	8-8	34	739.	42.8	5.8	581.
0032434 ER	10 Sec	8-9	34	1590.	101.5	6.4	968.
	1000 Sec	8-10	34	898.	46.0	5.1	611.
0033174 ER	10 Sec	8-11	12	1104.	53.8	4.9	1180.
	1000 Sec	8-12	12	748.	40.8	5.5	563.

SECTION III

STATISTICAL APPROACH

Data from testing of motors 0031064, 0031134, 0032434, 0033174 and Grain 131 are used in composite regressions in this report. Although Sunflower and Radford powder lots are combined in these statistical analyses, covariance analysis indicates that the lots are dissimilar and technically should not be combined (See Tables 3-1 and 3-2). However, based on Service Engineerings' request composite regressions were made. These tables represent stored test data including 1973 testing where this was available (i.e. low rate tensile).

A linear trend analysis has been used throughout. Variation in some test data is very large. "Significant" in this report refers to the statistical significance of "t" or slope.

Motors have not been identified on the data plots since the composite regressions represent the average of test data for that age. The limits about regression change the scale of values so that it is difficult to make direct comparisons between motors and between parameters.

TABLE 3-1

STAGE 3 DISSECTED MOTORS

TEST	TEST PARAMETER	13 SUNFLOWER MOTORS SLOPE	F	t	3 RAD MOTORS SLOPE	F	t	ANALYSIS OF COVARIANCE SLOPE	B_o	Total
TENSILE 2 in/min	SM	+	NS	NS	+	S	S	NS	NS	NS
	EM	-	S	S	-	S	S	NS	S	S
	ER	-	S	S	-	S	S	NS	S	S
	SR	+	S	S	+	S	S	NS	NS	NS
	E	+	S	S	+	S	S	NS	S	S
TENSILE 1750 in/min 300 psi	SM	+	S	S	+	NS	NS	NS	S	NS
	EM	-	NS	NS	+	NS	NS	NS	S	S
	ER	-	NS	NS	+	S	NS	NS	S	S
	SR	+	S	S	+	S	NS	NS	NS	NS
	E	-	S	NS	-	NS	NS	NS	NS	NS
STRESS RELAXATION 3%	E(t) 10 sec	+	S	S	+	S	S	NS	S	S
	E(t) 1000 sec	+	S	S	+	S	S	NS	S	S
CREEP 7 lb	1000 sec	-	S	NS	-	S	NS	NS	S	S
	10000 sec	+	S	S	-	S	S	S	S	S
HARDNESS Shore A	10 sec	-	S	NS	-	S	NS	NS	NS	NS

S = SIGNIFICANT DIFFERENCE
NS = NOT SIGNIFICANT
B_o = INTERCEPT

TABLE 3-2

INDIVIDUAL SUNFLOWER MOTORS VS 13 MOTOR COMPOSITE AND
INDIVIDUAL RAD MOTORS VS 3 RAD MOTOR COMPOSITE
STRAIN AT MAX STRESS

n			Individual Motor Statistics			Analysis of Covariance		
			Slope	F	t	Slope	Intercept	Total
45	Sunflower vs	0031036	-	S	S	NS	S	S
45		0031057	-	S	S	S	S	S
50		0031064	-	S	S	NS	S	S
45		0031097	-	S	S	NS	S	S
49		0031134	+	S	S	S	S	S
45		0031136	+	S	S	S	NS	S
45		0031158	-	S	S	NS	S	S
10		0032107	-	S	S	NS	NS	NS
10		0032116	-	S	S	S	NS	S
10		0032133	-	NS	NS	NS	S	S
10		0032137	-	NS	NS	NS	S	S
10		0032140	-	S	S	NS	NS	NS
45		0032248	-	S	S	S	S	S
50	RAD vs	0032434	-	NS	NS	NS	NS	NS
42		0032831	-	S	S	S	S	S
20		0033174	-	NS	S	NS	S	S

SECTION IV

LOW RATE TENSILE

The specimens used were modified JANNAF dogbones 1/4" thick in a Class B grip and tested in tension. The Instron crosshead speed was 2 in/min (strain rate 0.667 in/in min).

Regression analyses of the 5 motor composite (motors 31064, 31104, 32434, 33174 and Grain 131) are shown in Figures 4-1 thru 4-5. Only strain at rupture does not show a significant increase.

Individual motors do not show the same trend for strain at maximum stress. Motors 31064 (Figure 4-6) and 33174 (Figure 4-9) show a significant decrease; motors 31134 (Figure 4-7) and Grain 131 (Figure 4-10) show a significant increase; and motor 32434 (Figure 4-8) does not exhibit a significant change.

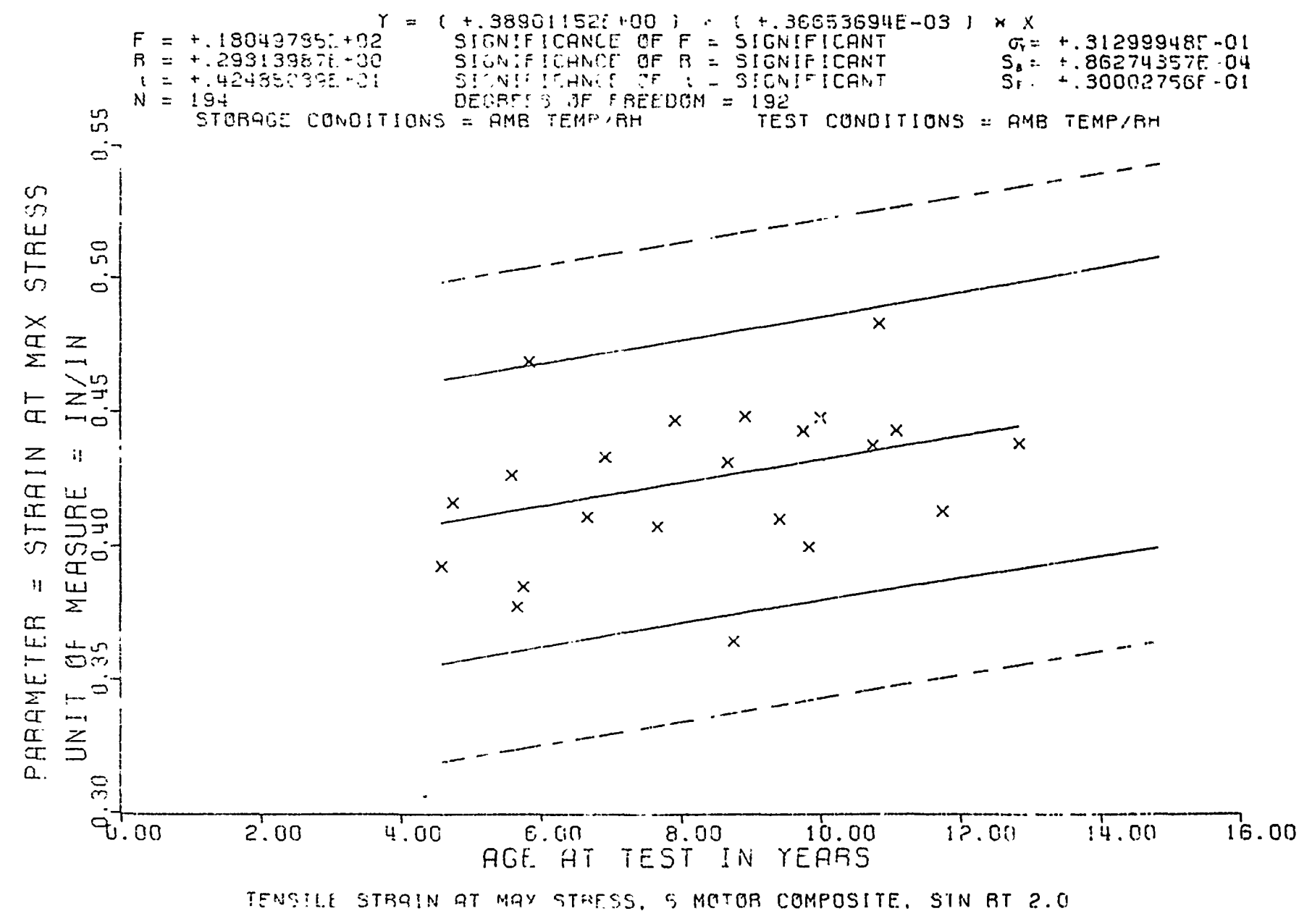
When these analyses are examined for the relationship between 1968 and 1973, it is evident that the data are quite dissimilar. In no instance did the 1973 data show equivalence with the 1968 data.

Failure envelopes were plotted by the computer (Figures 4-11 thru 4-15). All motors showed a point of coincidence at approximately 16% strain, but diverge on either side of the small area of agreement.

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
(55.0S)	10S
57.0	10
67.0	10
68.0	10
69.0	5
70.0	10
80.0	19
83.0	15
92.0	20
95.0	10
104.0	15
105.0	5
107.0	10
113.0	5
117.0	5
118.0	5
120.0	5
129.0	5
130.0	5
133.0	5
141.0	5
154.0	5

TENSILE STRAIN AT MAX STRESS, 5 MOTOR COMPOSITE, STN RT 2.0



TENSILE STRAIN AT MAX STRESS, 5 MOTOR COMPOSITE, SIN RT 2.0

FIGURE 4-1

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
(55.0S)	10S
57.0	10
67.0	10
68.0	10
69.0	5
70.0	10
80.0	19
83.0	15
92.0	20
95.0	10
104.0	15
105.0	5
107.0	10
113.0	5
117.0	5
118.0	5
120.0	5
129.0	5
130.0	5
133.0	5
141.0	5
154.0	5

TENSILE MAXIMUM STRESS, 5 MOTOR COMPOSITE, STN RT 2.0

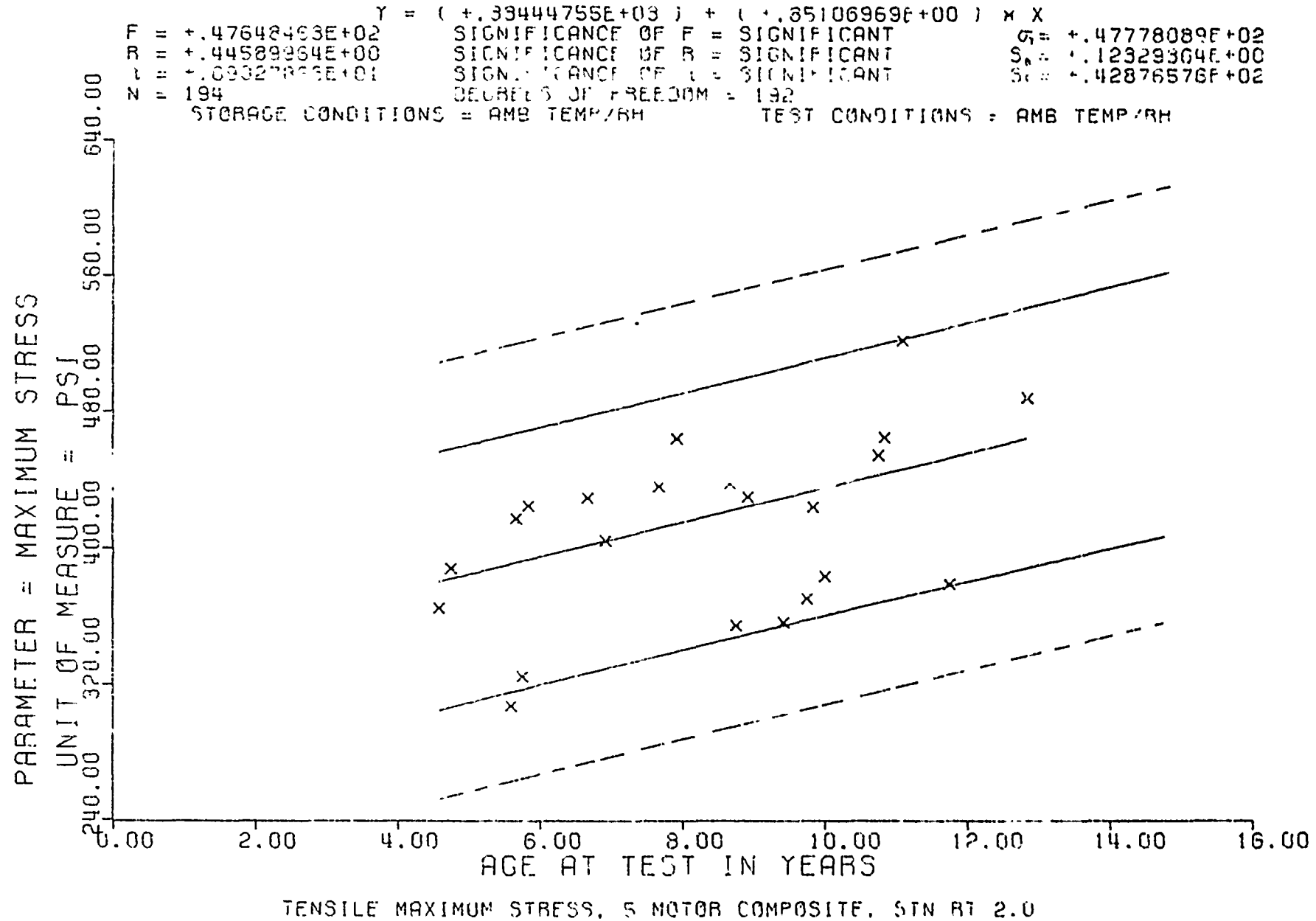

Y = (+.33444755E+03) + (+.85106969E+00) * X
F = +.47648463E+02
SIGNIFICANCE OF F = SIGNIFICANT
σ = +.47778089E+02
R = +.44589964E+00
SIGNIFICANCE OF R = SIGNIFICANT
N = 194
DEGREES OF FREEDOM = 192
STORAGE CONDITIONS = AMB TEMP/RH
TEST CONDITIONS = AMB TEMP/RH
PARAMETER = MAXIMUM STRESS
UNIT OF MEASURE = PSI
240.00
320.00
400.00
480.00
560.00
640.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST IN YEARS
TENSILE MAXIMUM STRESS, 5 MOTOR COMPOSITE, STN AT 2.0

FIGURE 4-2

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
(55.0S)	10S
57.0	10
67.0	10
68.0	10
69.0	5
70.0	10
80.0	19
83.0	15
92.0	20
95.0	10
104.0	15
105.0	5
107.0	10
113.0	5
117.0	5
118.0	5
120.0	5
129.0	5
130.0	5
133.0	5
141.0	5
154.0	5

TENSILE STRAIN AT RUPTURE, 5 MOTOR COMPOSITE, STN RT 2.0

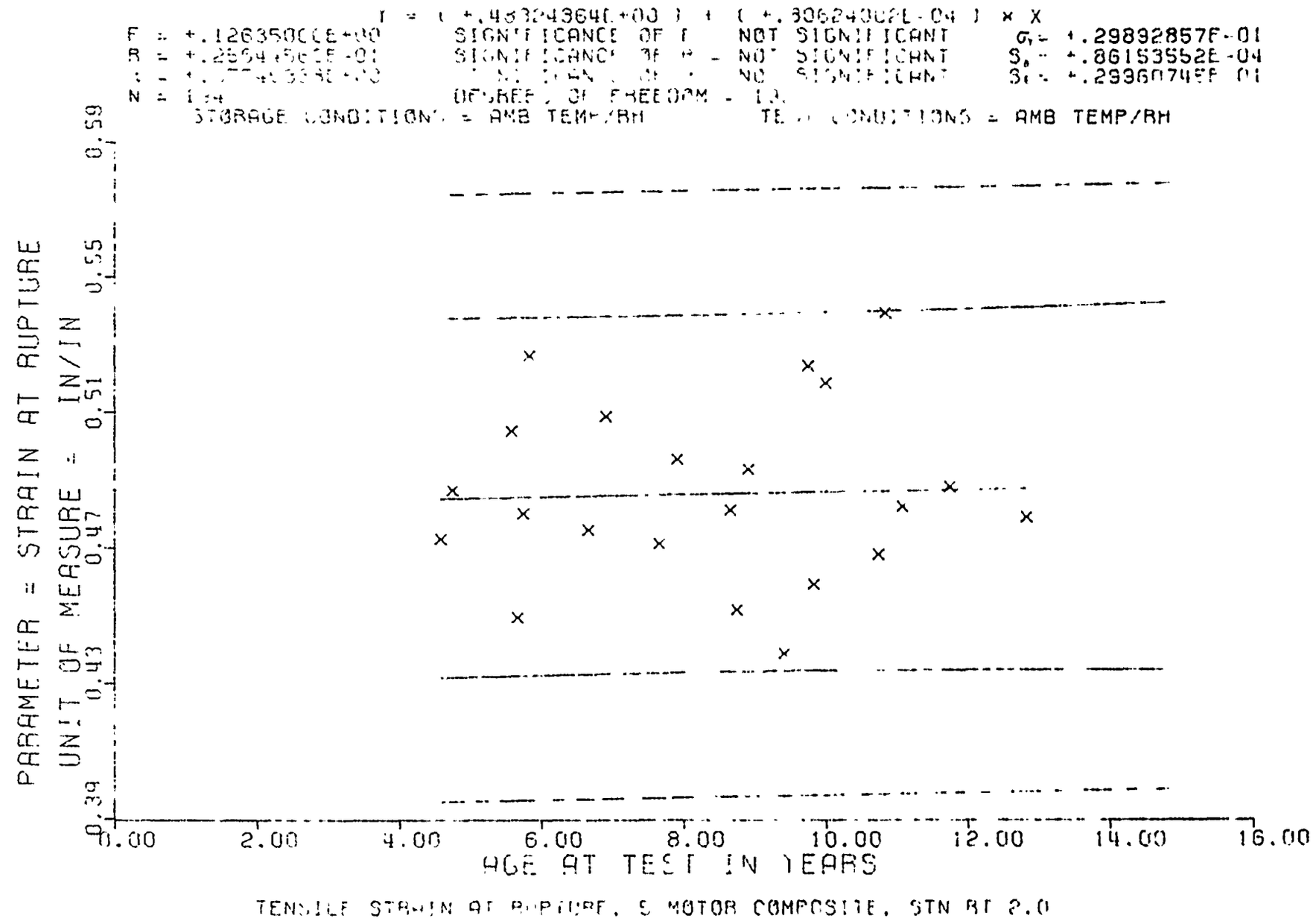

Y = (+.48324364E+00) + (+.80624002E-04) * X
F = +.12635001E+00 SIGNIFICANCE OF F NOT SIGNIFICANT σ = +.29892857E-01
R = +.25647561E-01 SIGNIFICANCE OF R = NOT SIGNIFICANT S0 = +.86153552E-04
S = +.[illegible] [illegible] NOT SIGNIFICANT S1 = +.29360745E-01
N = 154 DEGREE OF FREEDOM = 152
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH
PARAMETER = STRAIN AT RUPTURE
UNIT OF MEASURE = IN/IN
0.59
0.55
0.51
0.47
0.43
0.39
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST IN YEARS
TENSILE STRAIN AT RUPTURE, 5 MOTOR COMPOSITE, STN AT 2.0

FIGURE 4-3

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
(55.0S)	10S
57.0	10
67.0	10
68.0	10
69.0	5
70.0	10
80.0	19
83.0	15
92.0	20
95.0	10
104.0	15
105.0	5
107.0	10
113.0	5
117.0	5
118.0	4
120.0	5
129.0	5
130.0	5
133.0	5
141.0	5
154.0	5

TENSILE STRESS AT RUPTURE, 5 MOTOR COMPOSITE, STN KT 2.0

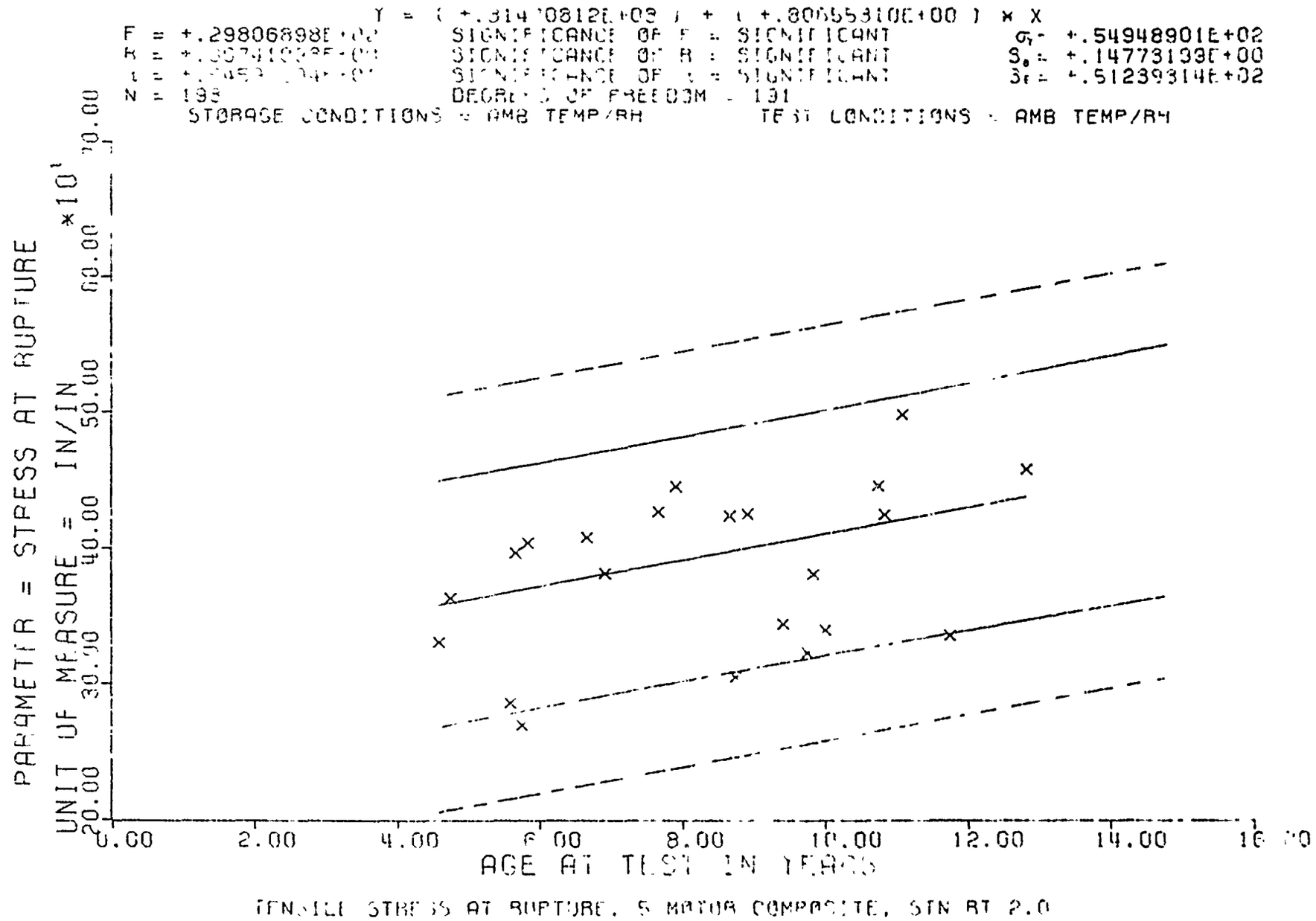

Y = (+.31408812E+03) + (+.80655310E+00) * X
F = +.29806898E+02
SIGNIFICANCE OF F = SIGNIFICANT
σr = +.54948901E+02
R = +.80741023E+00
SIGNIFICANCE OF R = SIGNIFICANT
So = +.14773139E+00
N = 133
DEGREES OF FREEDOM = 131
STORAGE CONDITIONS = AMB TEMP/RH
TEST CONDITIONS = AMB TEMP/RH
PARAMETER = STRESS AT RUPTURE
UNIT OF MEASURE = IN/IN *10¹
20.00
30.00
40.00
50.00
60.00
70.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST IN YEARS
TENSILE STRESS AT RUPTURE, S MATRIX COMPOSITE, STN AT 2.0

FIGURE 4-4

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
(55.05)	10S
57.0	10
67.0	10
68.0	10
69.0	5
70.0	10
80.0	19
83.0	15
92.0	20
95.0	10
104.0	15
105.0	5
107.0	10
113.0	5
117.0	5
118.0	5
120.0	5
129.0	5
130.0	5
133.0	5
141.0	5
154.0	5

TENSILE MODULUS, 5 MOTOR COMPOSITE, STN RT 2.0

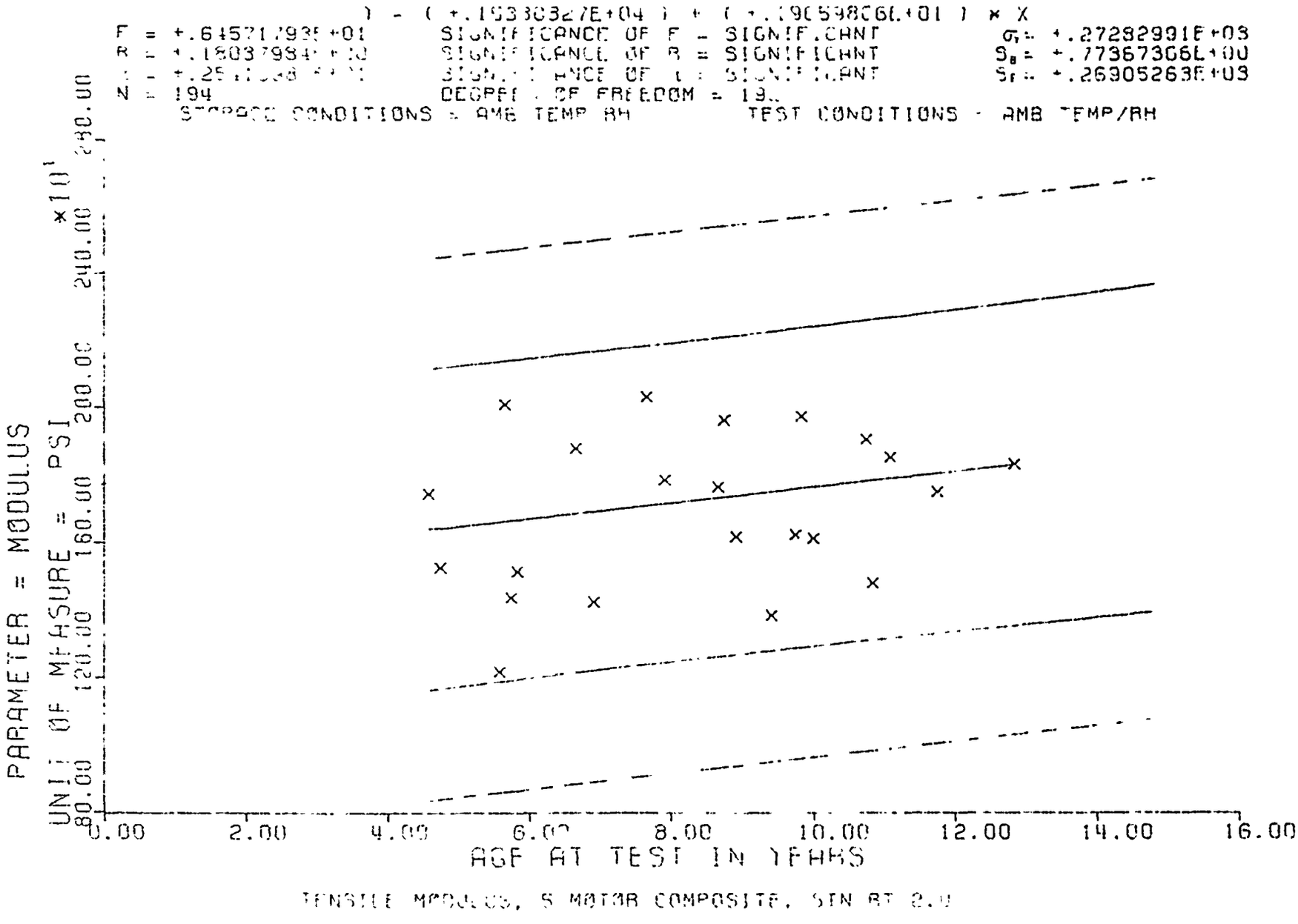
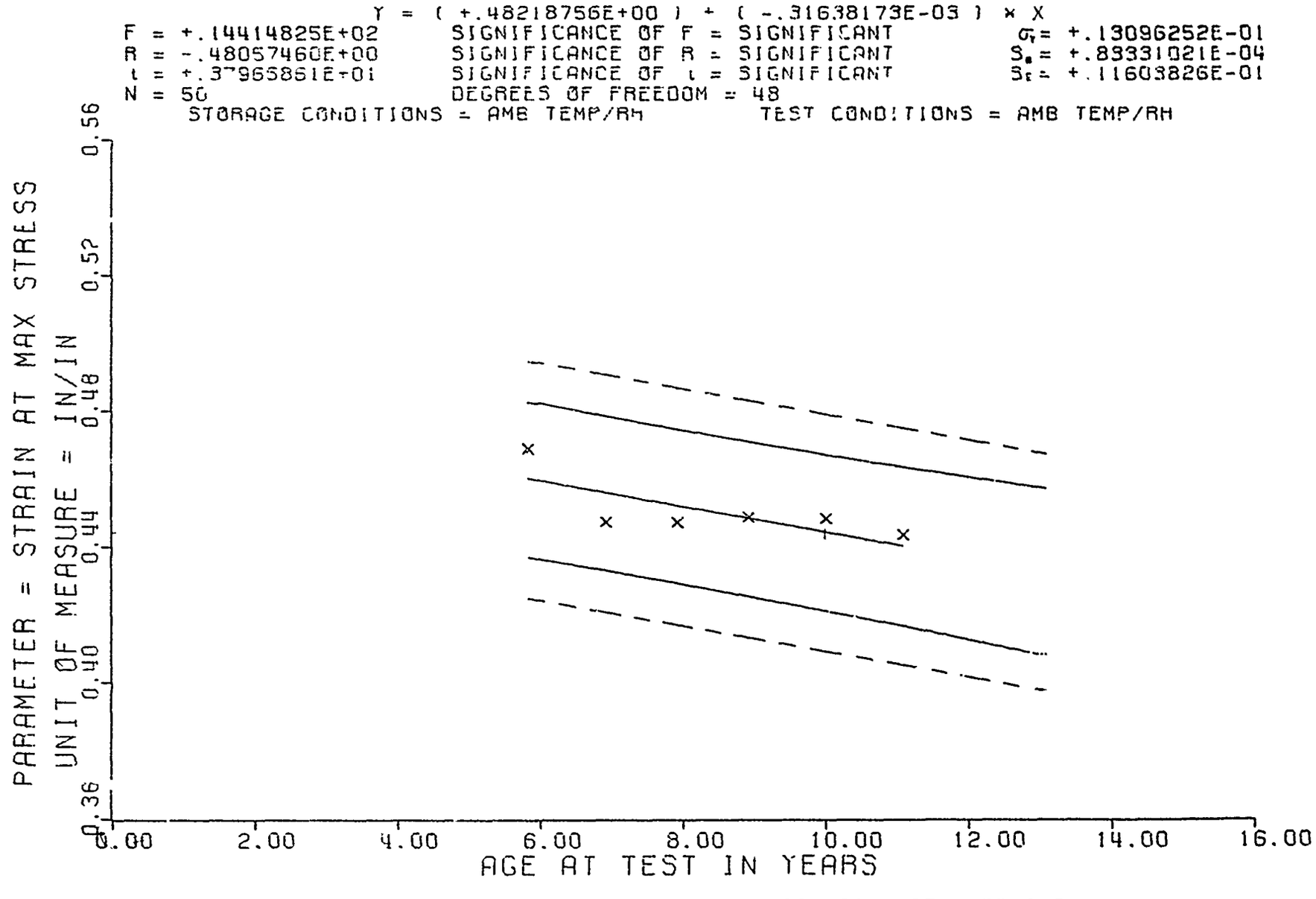

) - (+.1933827E+04) + (+.1965986E+01) * X
F = +.6457179E+01
SIGNIFICANCE OF F = SIGNIF.CHNT
σr = +.2728299E+03
R = +.1803798E+00
SIGNIFICANCE OF R = SIGNIFICHNT
Sa = +.7736730E+00
N = 194
DEGREE OF FREEDOM = 19..
Sf = +.2690526E+03
STORAGE CONDITIONS = AMB TEMP RH
TEST CONDITIONS - AMB TEMP/RH
PARAMETER = MODULUS
UNIT OF MEASURE = PSI
*10¹
240.00
200.00
160.00
120.00
80.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST IN YEARS
TENSILE MODULUS, S MOTOR COMPOSITE, STN AT 2.0

FIGURE 4-5

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	N SAMPLES
[illegible]	135
[illegible]	10
[illegible]	10
127.0	10
129.0	5
132.0	5

TENSILE STRAIN AT MAX STRESS, MOTOR & COBIOGA, STRAIN RT 2.0



TENSILE STRAIN AT MAX STRESS, MOTOR # 0031064, STRN RT 2.0

FIGURE 4-6

*** SAMPLE SIZE SUMMARY ***

[illegible] (DEGREES)	N SAMPLES
[illegible]	[illegible]
20.0	
[illegible]	1
104.0	10
117.0	5
130.0	5

TENSILE STRAIN AT MAX STRESS, MOTOR # 0031134, STRAIN RT 2.0

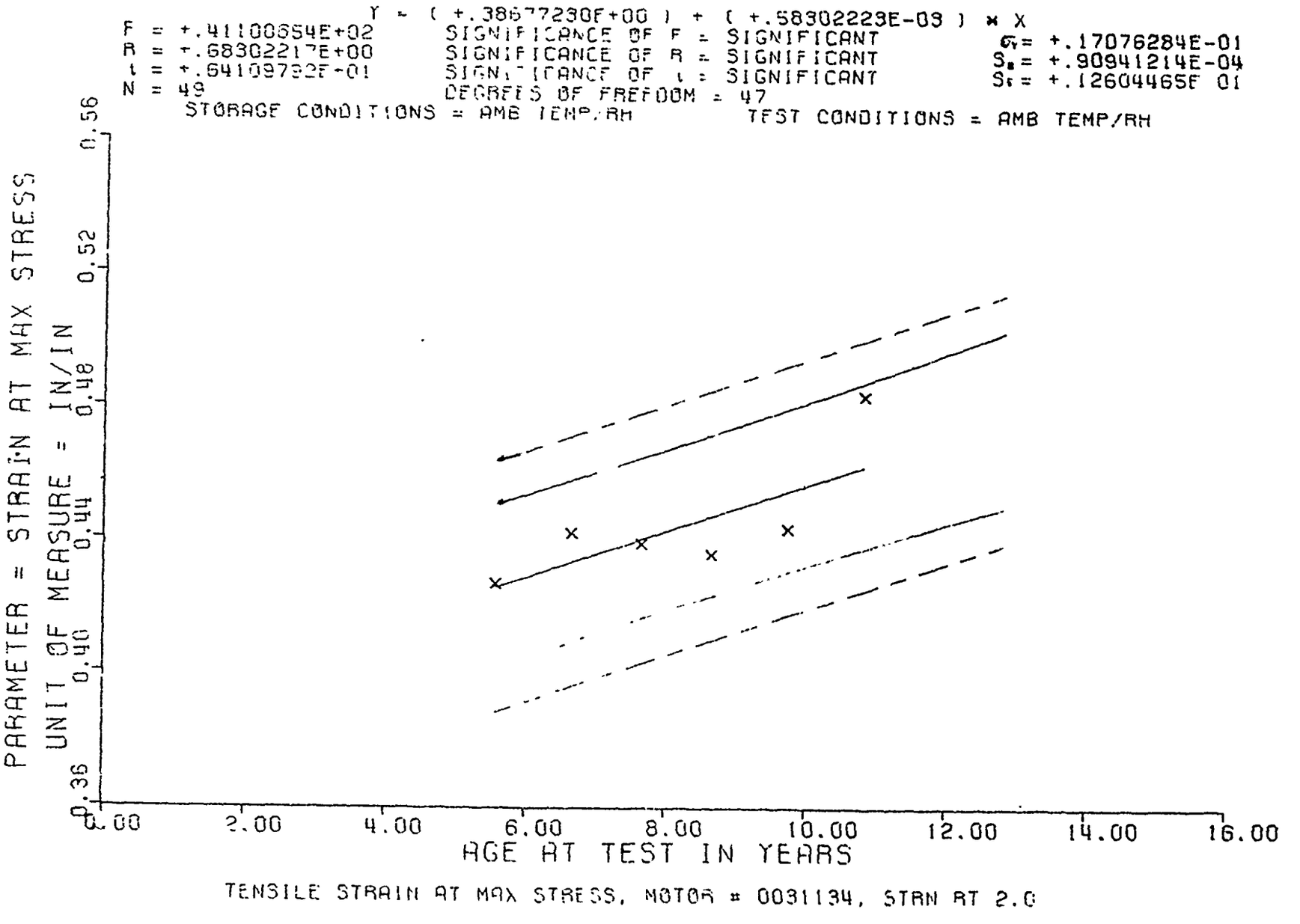

Y = (+.38677230E+00) + (+.58302223E-03) * X
F = +.41108654E+02
R = +.68302217E+00
t = +.64109792E-01
N = 49
SIGNIFICANCE OF F = SIGNIFICANT
SIGNIFICANCE OF R = SIGNIFICANT
SIGNIFICANCE OF t = SIGNIFICANT
DEGREES OF FREEDOM = 47
σY = +.17076284E-01
Sa = +.90941214E-04
Sb = +.12604465E 01
STORAGE CONDITIONS = AMB TEMP/RH
TEST CONDITIONS = AMB TEMP/RH
PARAMETER = STRAIN AT MAX STRESS
UNIT OF MEASURE = IN/IN
0.36
0.40
0.44
0.48
0.52
0.56
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST IN YEARS
TENSILE STRAIN AT MAX STRESS, MOTOR = 0031134, STRN RT 2.0

FIGURE 4-7

*** SAMPLE SIZE SUMMARY ***

(POINTS)	SAMPLE
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
125.0	5
110.0	[illegible]

TENSILE STRENGTH AT MAX STRESS, MOTOR = 0.02434, STEP = 2.0

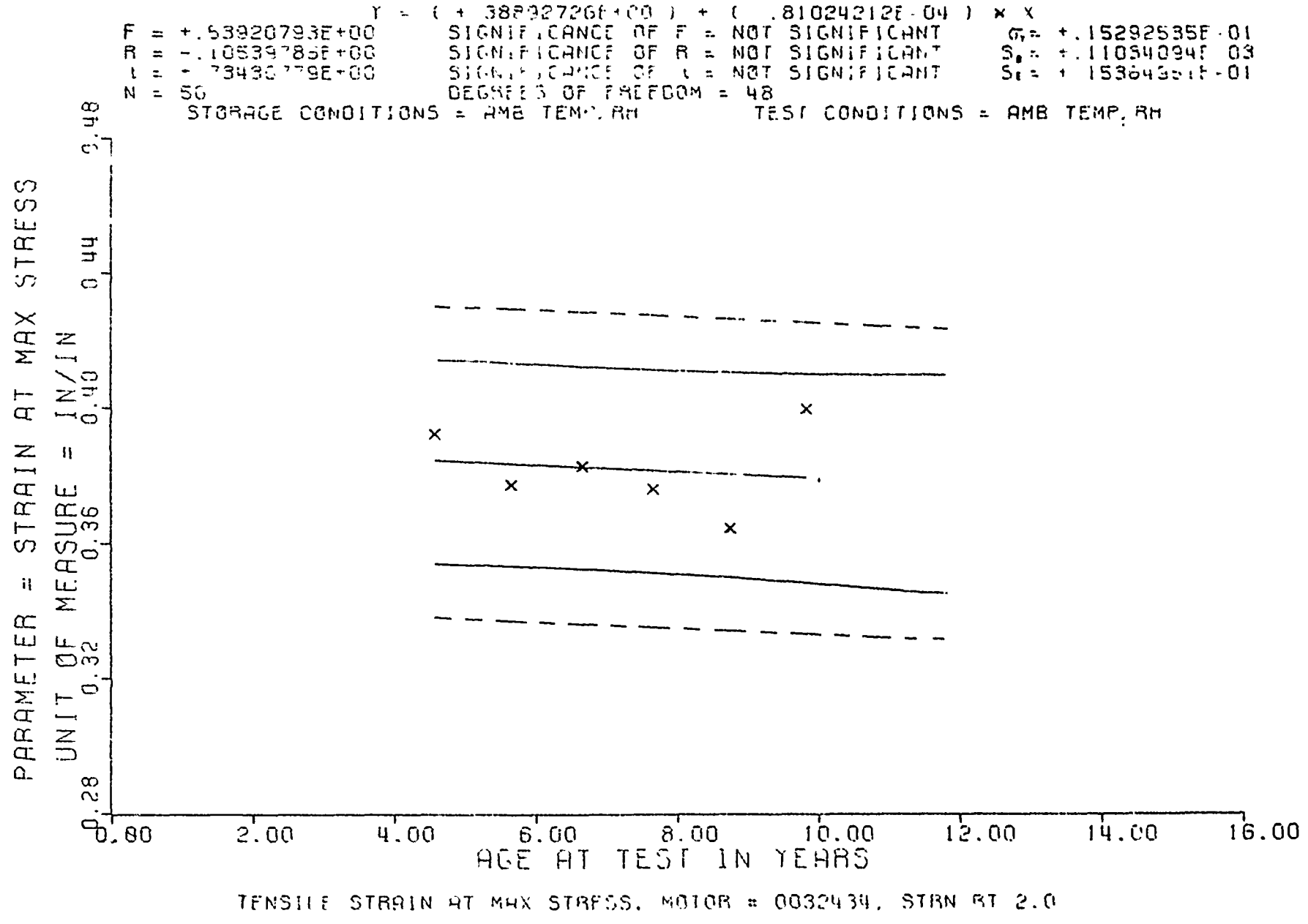

Y = (+ 38232726E+00) + (.81024212E-04) × X
F = +.53920793E+00 SIGNIFICANCE OF F = NOT SIGNIFICANT σ = +.15292535E-01
R = -.10539785E+00 SIGNIFICANCE OF R = NOT SIGNIFICANT
N = 50 DEGREES OF FREEDOM = 48
STORAGE CONDITIONS = AMB TEMP, RH TEST CONDITIONS = AMB TEMP, RH
PARAMETER = STRAIN AT MAX STRESS
UNIT OF MEASURE = IN/IN
0.28
0.32
0.36
0.40
0.44
0.48
0.80
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST IN YEARS
TENSILE STRAIN AT MAX STRESS, MOTOR = 0032434, STRN RT 2.0

FIGURE 4-8

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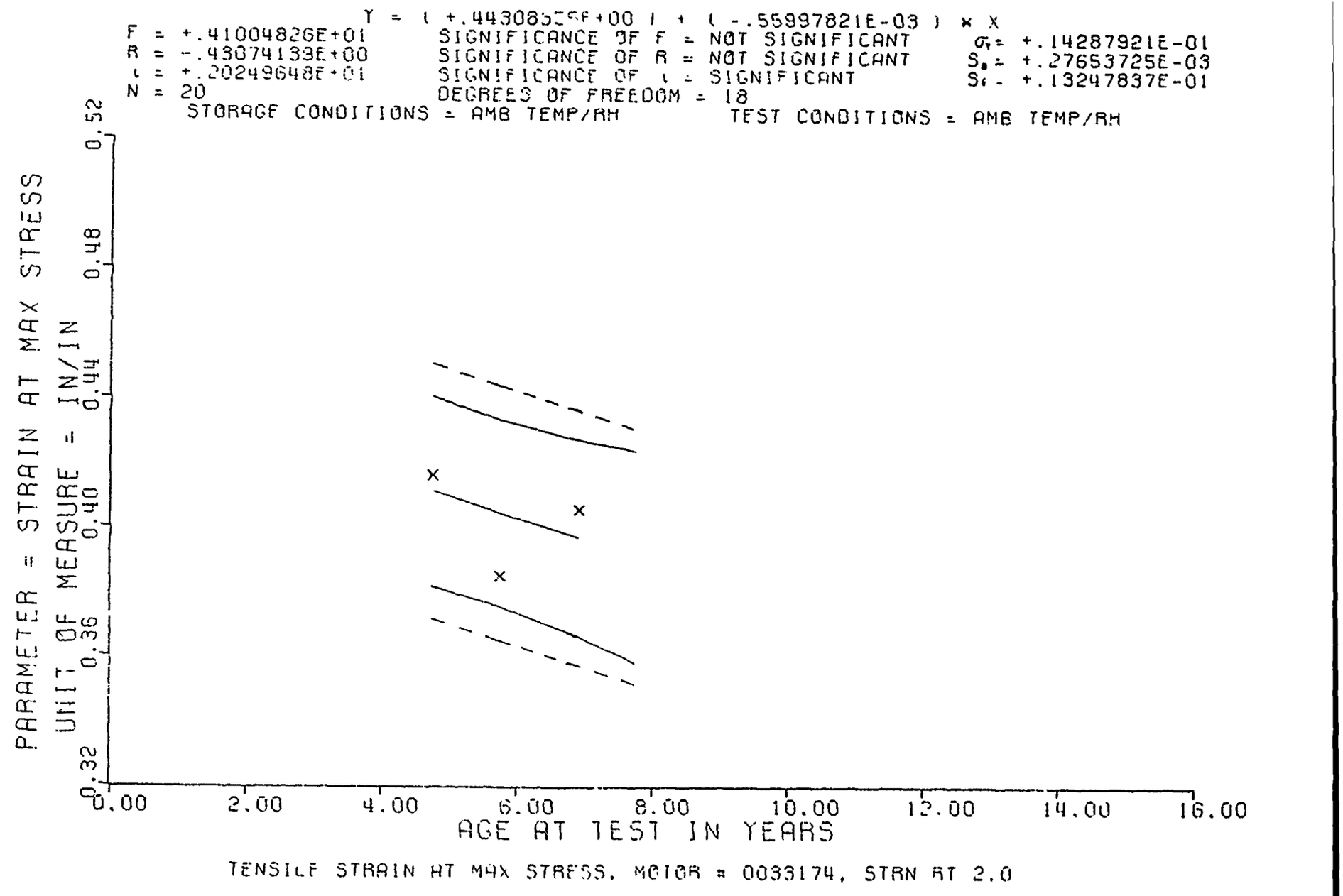

Y = (+.44308[illegible]E+00) + (-.55997821E-03) * X
F = +.41004826E+01
R = -.43074133E+00
t = +.20249648E+01
N = 20
SIGNIFICANCE OF F = NOT SIGNIFICANT
SIGNIFICANCE OF R = NOT SIGNIFICANT
SIGNIFICANCE OF t = SIGNIFICANT
DEGREES OF FREEDOM = 18
σ = +.14287921E-01
S = +.27653725E-03
S = +.13247837E-01
STORAGE CONDITIONS = AMB TEMP/RH
TEST CONDITIONS = AMB TEMP/RH
PARAMETER = STRAIN AT MAX STRESS
UNIT OF MEASURE = IN/IN
0.32
0.36
0.40
0.44
0.48
0.52
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST IN YEARS
TENSILE STRAIN AT MAX STRESS, MOTOR = 0033174, STRN AT 2.0

FIGURE 4-9

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NO. SAMPLES
(104.0)	55
113.0	5
124.0	5
141.0	5
154.0	5

TENSILE STRAIN AT MAX STRESS, METHOD # CODE 131, STEP PT 2.0

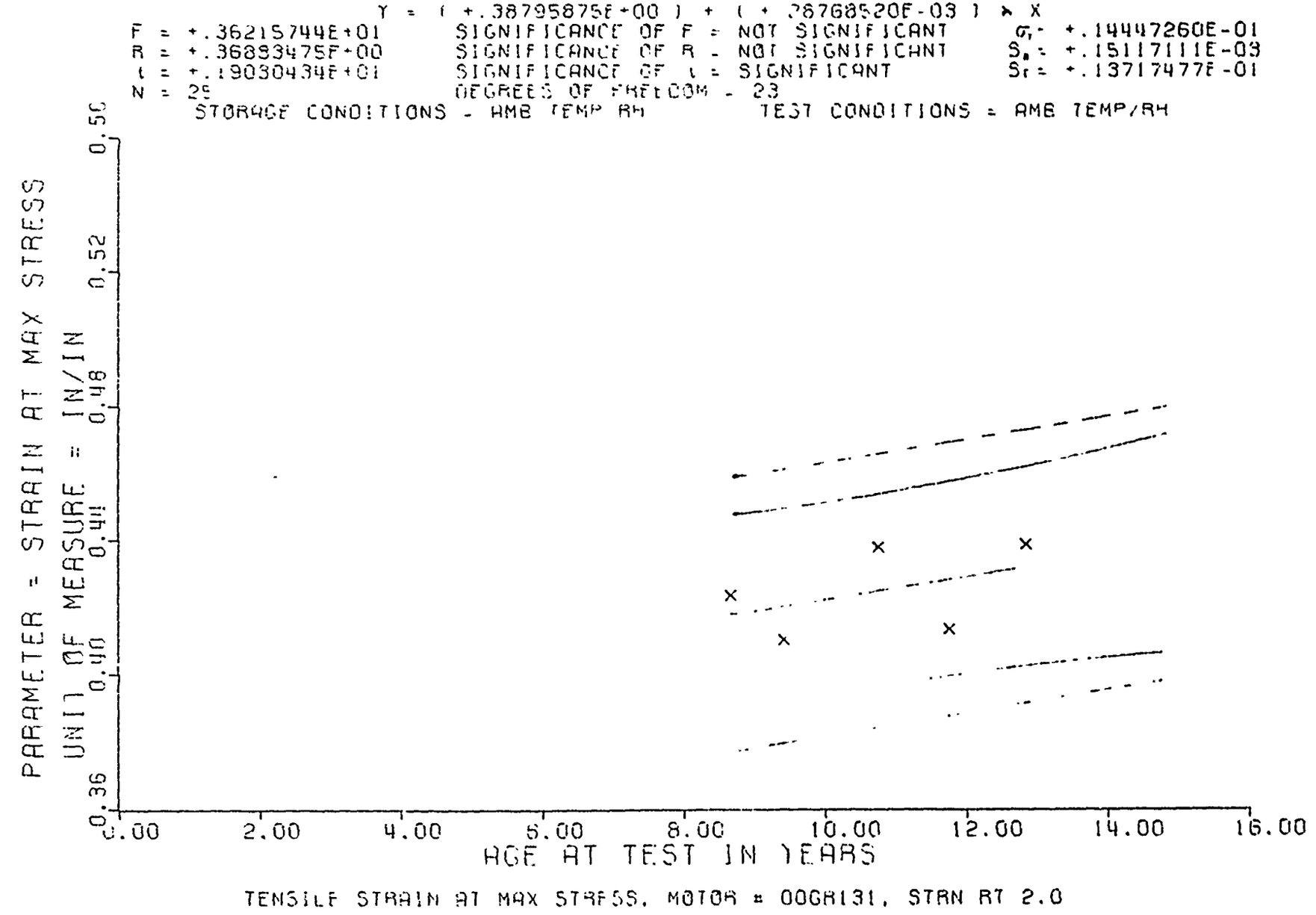

Y = (+.38795875E+00) + (+.28768520E-03) * X
F = +.36215744E+01 SIGNIFICANCE OF F = NOT SIGNIFICANT σ = +.14447260E-01
R = +.36883475E+00 SIGNIFICANCE OF R = NOT SIGNIFICANT Sa = +.15117111E-03
t = +.19030434E+01 SIGNIFICANCE OF t = SIGNIFICANT Sr = +.13717477E-01
N = 25 DEGREES OF FREEDOM = 23
STORAGE CONDITIONS = AMB TEMP RH TEST CONDITIONS = AMB TEMP/RH
PARAMETER = STRAIN AT MAX STRESS
UNIT OF MEASURE = IN/IN
0.36
0.40
0.44
0.48
0.52
0.56
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST IN YEARS
TENSILE STRAIN AT MAX STRESS, MOTOR = 00GR131, STRN RT 2.0

FIGURE 4-10

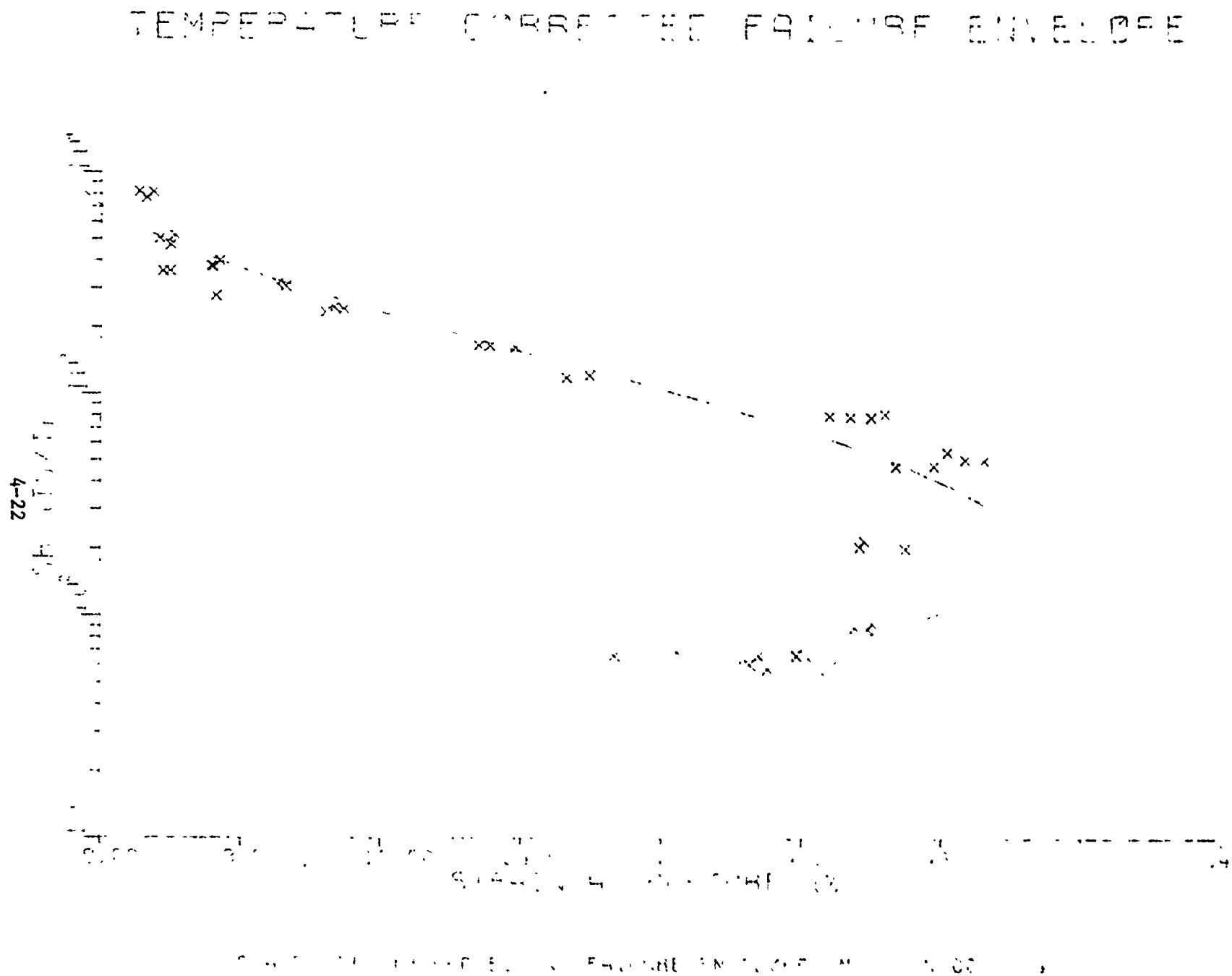


FIGURE 4-11

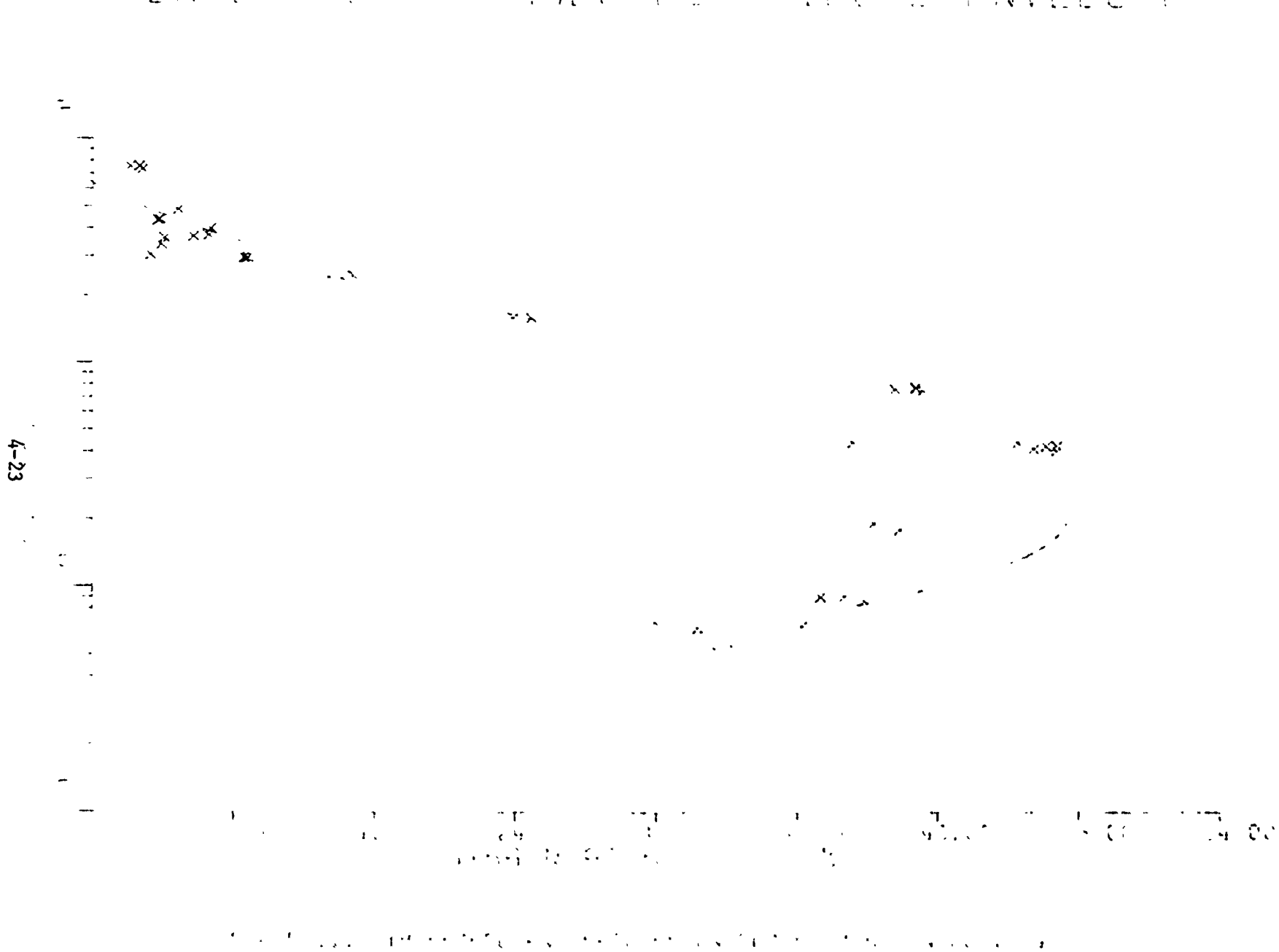


FIGURE 4-12

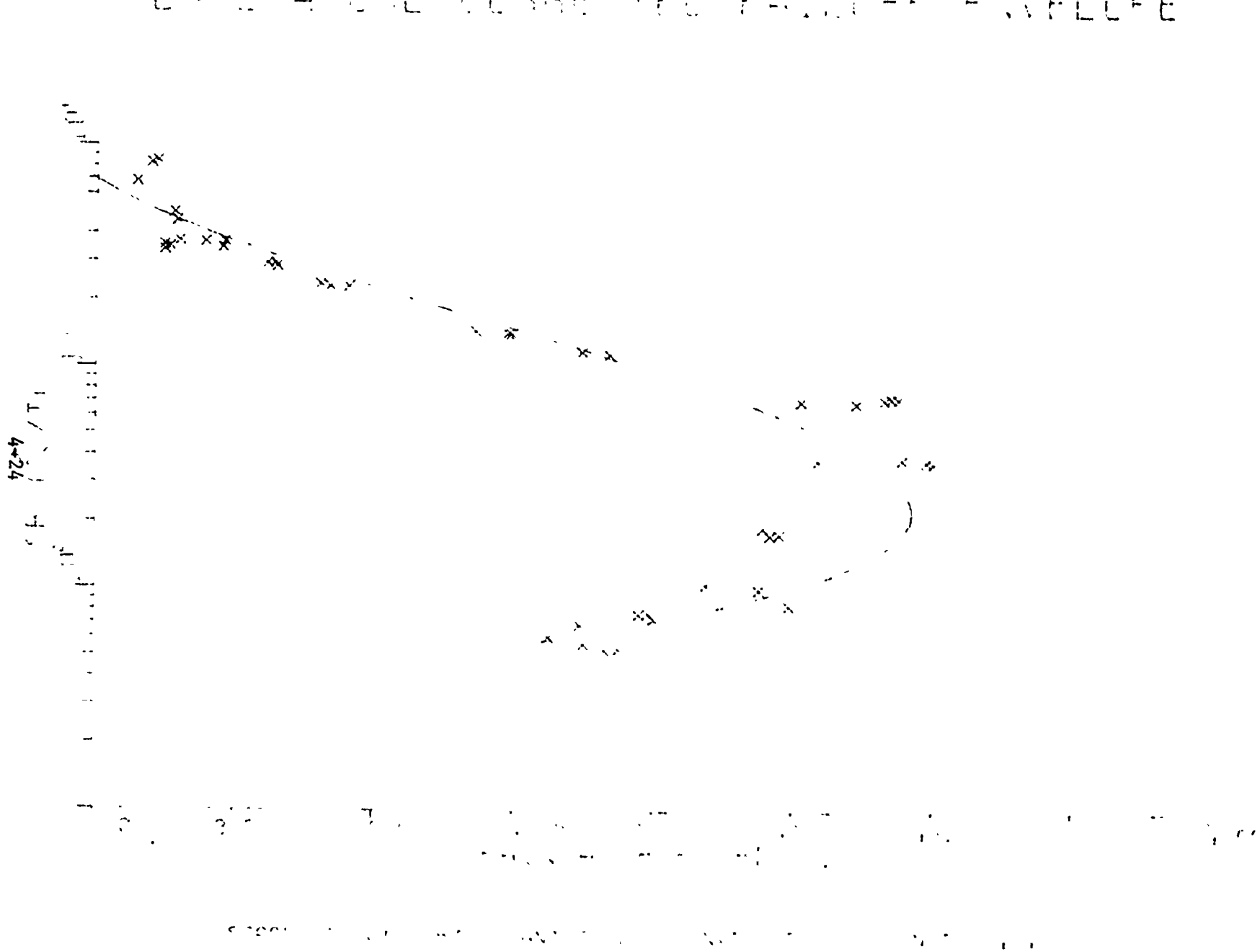


FIGURE 4-13



FIGURE 4-14

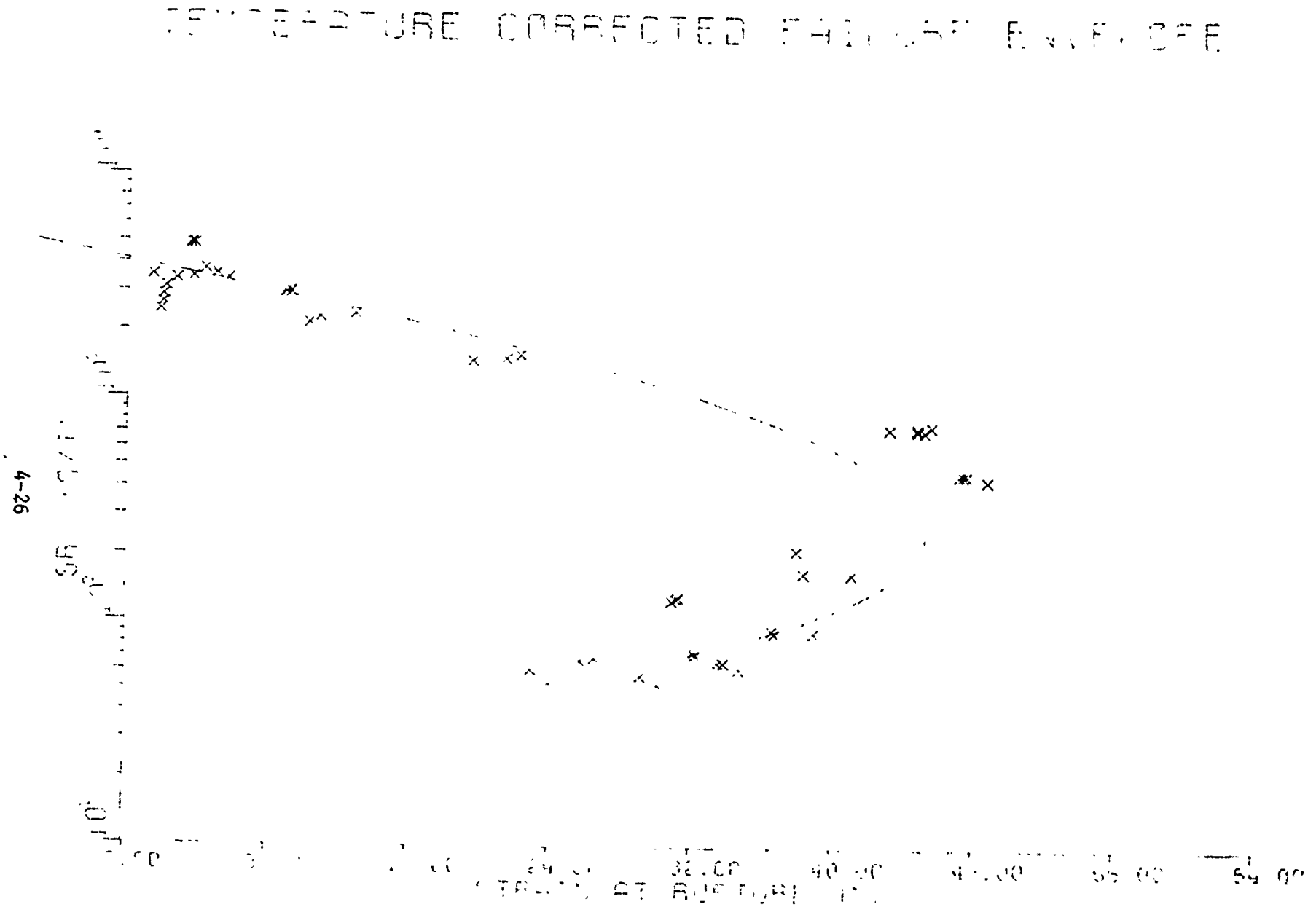


FIGURE 4-15

SECTION V

VERY LOW RATE TENSILE

The specimens used used were modified JANNAF dogbones 1/4" thick. Specimens were tested at a crosshead speed of 2×10^{-4} in/min (strain rate of $.67 \times 10^{-4}$ in/in/min) at a relative humidity of $50 \pm 5\%$. Equipment failure reduced the humidity which affected the data as shown in Table 5-1.

Regressions for the five motor composite are given in Figure 5-1 thru 5-5. Stresses show a significant decrease but modulus shows a significant increase. There is no significant change in strain.

There are differences between the data from low rate tensile and very low rate tensile data. Strain at maximum stress shows a significant increase at 2 in/min compared to an insignificant increase at 2×10^{-4} in/min. Maximum stress shows a significant increase at 2 in/min with no significant change at the lower rate. Both sets of data show a significant increase in modulus.

Motor 0C31064 shows a significant increase in strain at maximum stress (Figure 5-6). Other motors do not show a significant change (Figures 5-7 thru 5-10).

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
(57.0S)	11S
67.0	6
[illegible].0	5
70.0	6
83.0	5
84.0	10
86.0	5
93.0	5
96.0	10
99.0	10
104.0	5
105.0	5
106.0	5
108.0	5
117.0	5
119.0	5
121.0	5
129.0	5
131.0	5
134.0	5
142.0	5
155.0	5

TENSILE STRAIN AT MAX STRESS, 5 MOTOR COMPOSITE, STN RT 0.0002

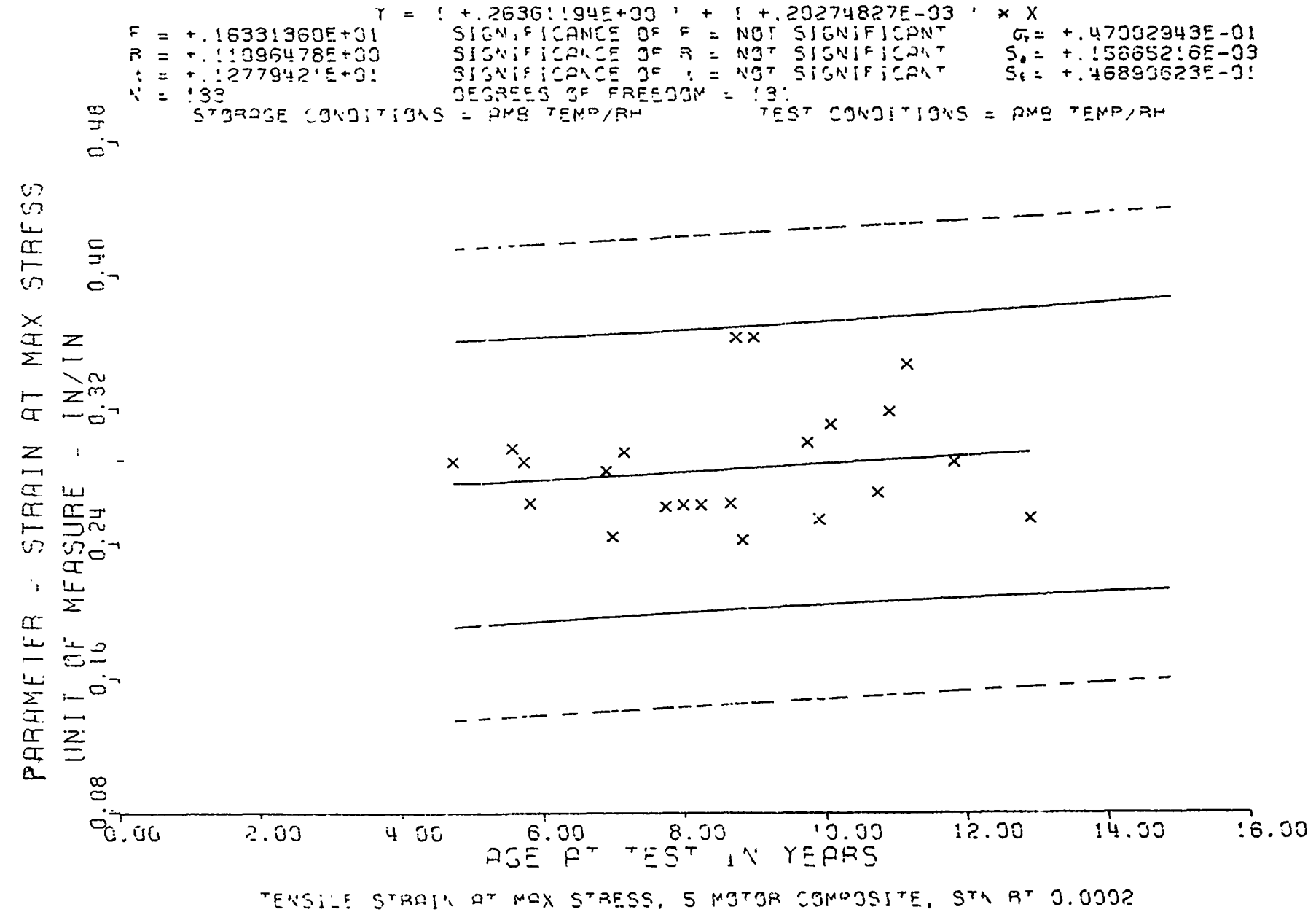

Y = (+.26361194E+00) + (+.20274827E-03) * X
F = +.16331360E+01 SIGNIFICANCE OF F = NOT SIGNIFICANT σ = +.47002943E-01
R = +.11096478E+00 SIGNIFICANCE OF R = NOT SIGNIFICANT S = +.15865216E-03
= +.1277942'E+01 SIGNIFICANCE OF = NOT SIGNIFICANT S = +.46890623E-01
= 139 DEGREES OF FREEDOM = 137
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH
PARAMETER - STRAIN AT MAX STRESS
UNIT OF MEASURE - IN/IN
0.48
0.40
0.32
0.24
0.16
0.08
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST IN YEARS
TENSILE STRAIN AT MAX STRESS, 5 MOTOR COMPOSITE, STN AT 0.0002

FIGURE 5-1

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
(57.-)S)	-11S
67.0	6
6[illegible].0	5
70.0	6
33.0	5
84.0	10
86.0	5
93.0	5
[illegible]6.0	10
99.0	10
104.0	5
105.0	5
106.0	5
108.0	5
117.0	[illegible]
119.0	5
121.0	5
129.0	5
131.0	5
134.0	5
142.0	5
155.0	5

TENSILE MAXIMUM STRESS, 5 MOTOR COMPOSITE, STN RT 0.0002

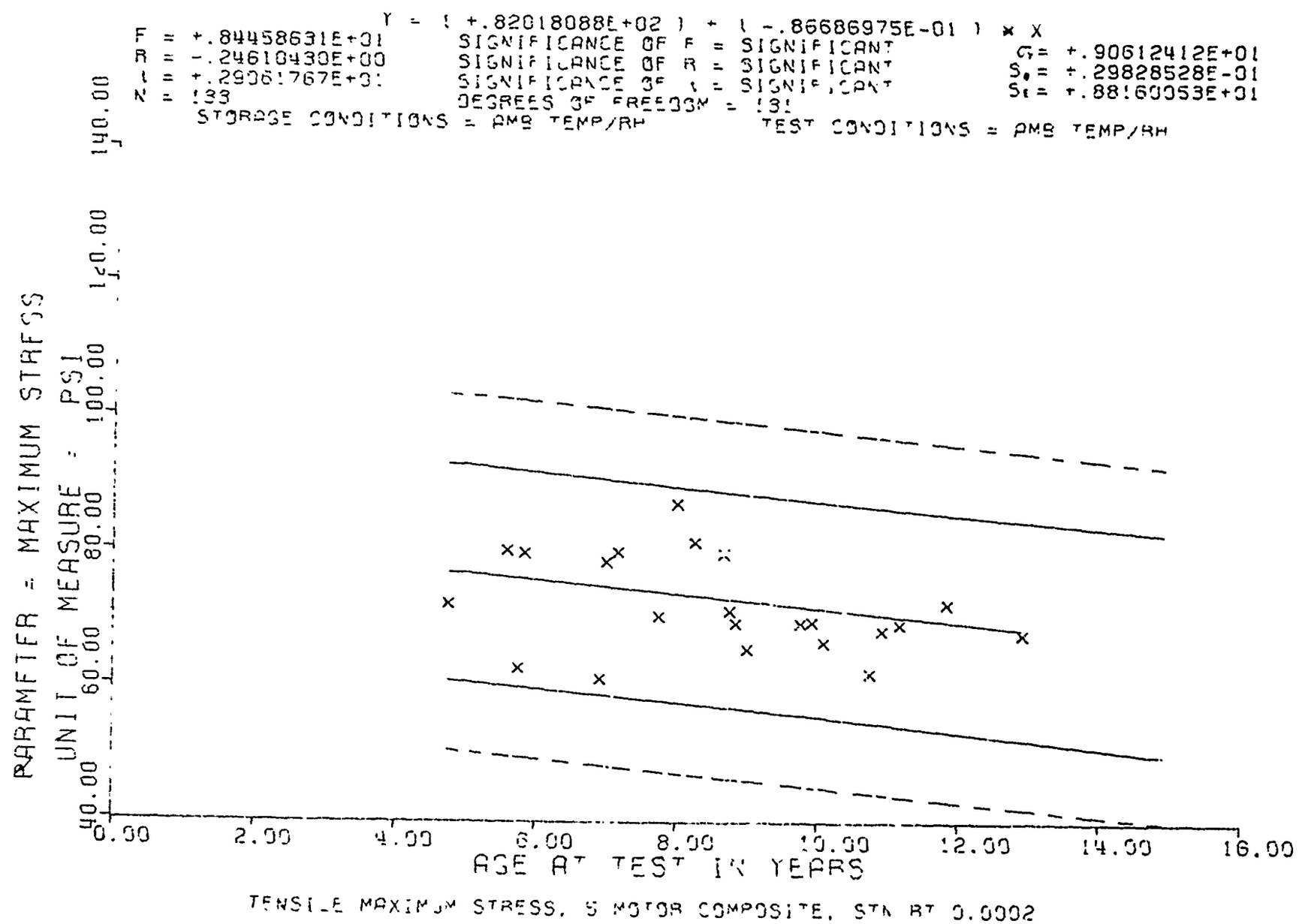

Y = (+.82018088E+02) + (-.86686975E-01) * X
F = +.844586J1E+01
R = -.24610430E+00
t = +.29061767E+01
N = 133
SIGNIFICANCE OF F = SIGNIFICANT
SIGNIFICANCE OF R = SIGNIFICANT
SIGNIFICANCE OF t = SIGNIFICANT
DEGREES OF FREEDOM = 131
STORAGE CONDITIONS = AMB TEMP/RH
TEST CONDITIONS = AMB TEMP/RH
PARAMETER = MAXIMUM STRESS
UNIT OF MEASURE = PSI
140.00
120.00
100.00
80.00
60.00
40.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST IN YEARS
TENSILE MAXIMUM STRESS, 5 MOTOR COMPOSITE, STN RT 0.0002

FIGURE 5-2

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
(57.0S)	115
67.0	6
69.0	5
70.0	6
83.0	5
84.0	10
86.0	5
93.0	5
96.0	10
99.0	10
104.0	5
105.0	5
106.0	5
108.0	5
117.0	5
119.0	5
121.0	5
129.0	5
131.0	5
134.0	5
142.0	5
155.0	5

TENSILE STRAIN AT RUPTURE, 5 MOTOR COMPOSITE, STN RT 0.0002

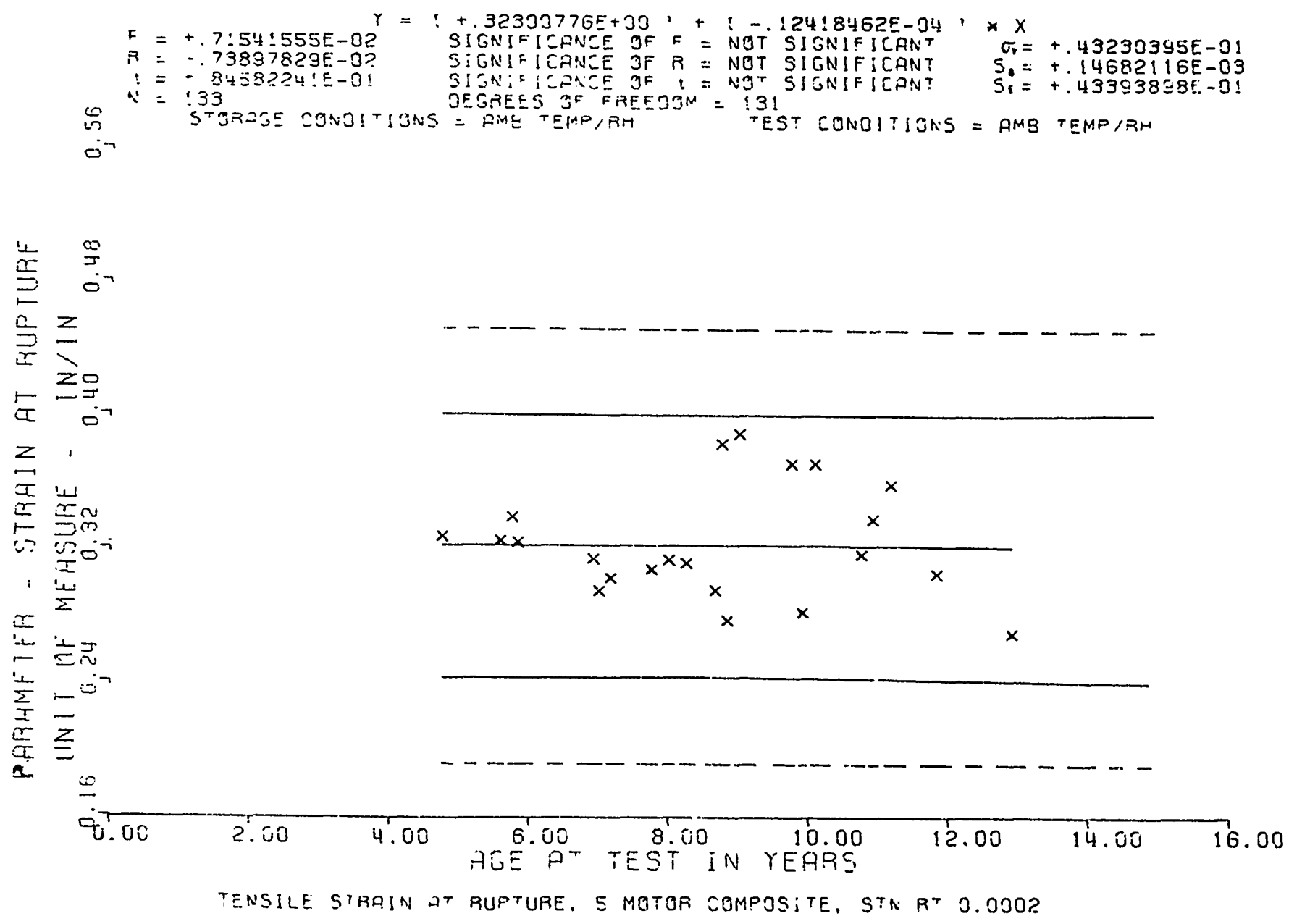

Y = (+.32303776E+00) + (-.12418462E-04) * X
F = +.71541555E-02
SIGNIFICANCE OF F = NOT SIGNIFICANT
σr = +.43230395E-01
R = -.73897829E-02
SIGNIFICANCE OF R = NOT SIGNIFICANT
Se = +.14682116E-03
t = +.84582241E-01
SIGNIFICANCE OF t = NOT SIGNIFICANT
St = +.43393898E-01
N = 133
DEGREES OF FREEDOM = 131
STORAGE CONDITIONS = AMB TEMP/RH
TEST CONDITIONS = AMB TEMP/RH
PARAMETER - STRAIN AT RUPTURE
UNIT OF MEASURE - IN/IN
0.56
0.48
0.40
0.32
0.24
0.16
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST IN YEARS
TENSILE STRAIN AT RUPTURE, 5 MOTOR COMPOSITE, STN RT 0.0002

FIGURE 5-3

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
(57.0S)	115
67.0	6
69.0	5
78.0	6
83.0	5
84.0	10
88.0	5
93.0	5
96.0	10
99.0	10
104.0	5
105.0	5
106.0	5
108.0	5
117.0	5
119.0	5
121.0	5
129.0	5
131.0	5
134.0	5
142.0	5
155.0	5

TENSILE STRESS AT RUPTURE, 5 MOTOR COMPOSITE, STN RT 0.0002

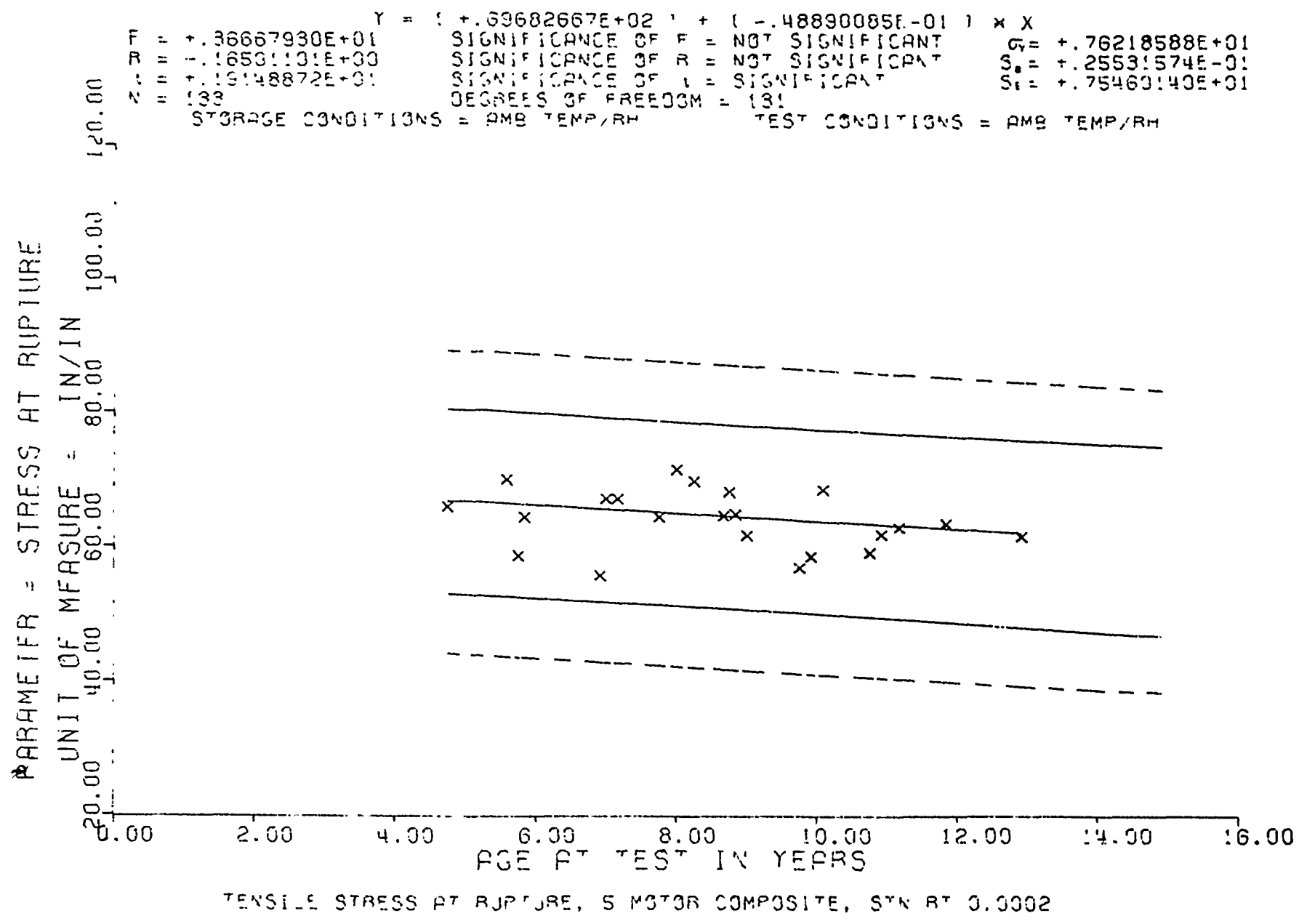
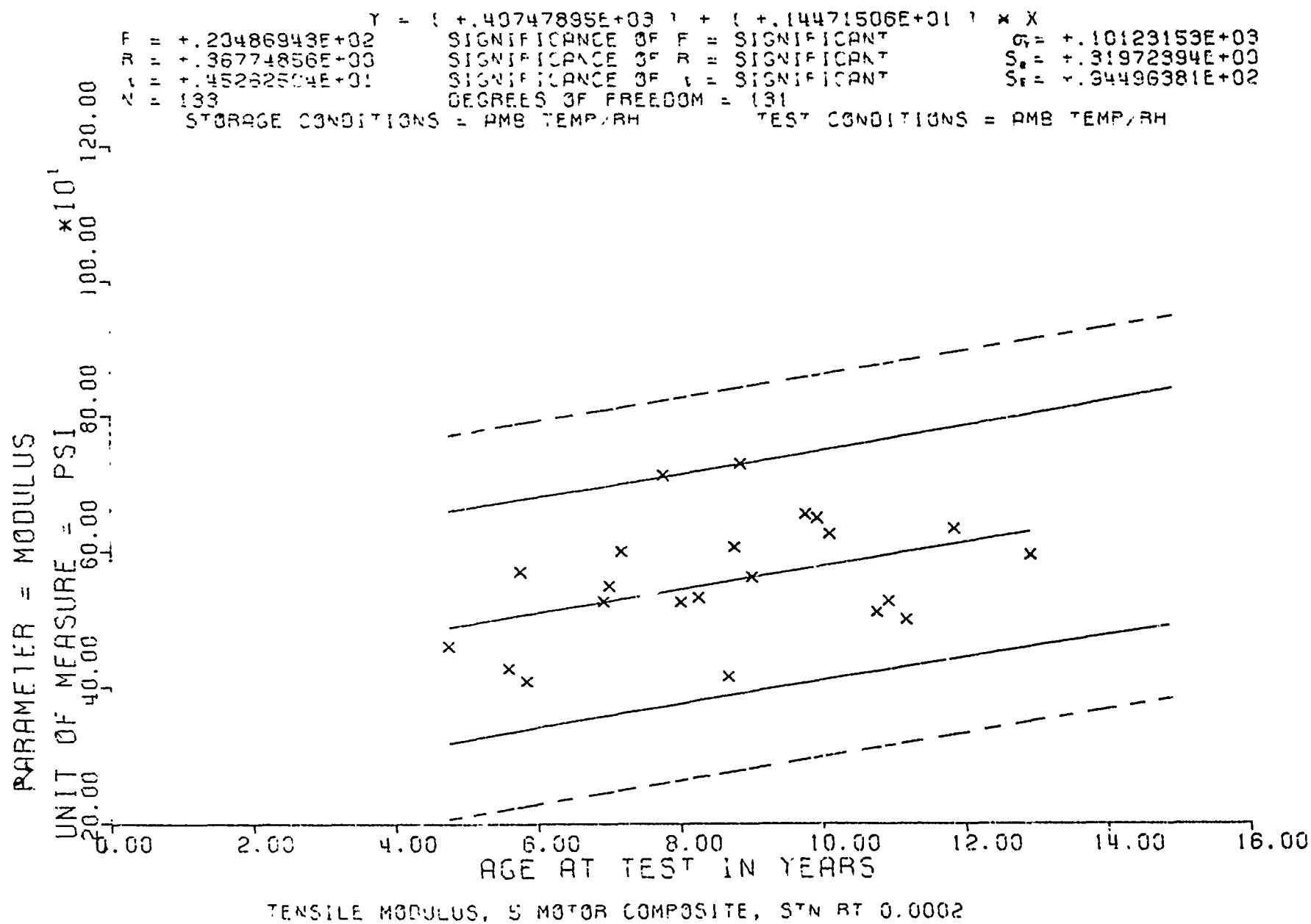

Y = (+.69682667E+02) + (-.48890085E-01) * X
F = +.36667930E+01 SIGNIFICANCE OF F = NOT SIGNIFICANT σ = +.76218588E+01
R = -.16501101E+00 SIGNIFICANCE OF R = NOT SIGNIFICANT S. = +.25531574E-01
N = 133 DEGREES OF FREEDOM = 131 St = +.75460140E+01
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH
PARAMETER = STRESS AT RUPTURE
UNIT OF MEASURE = IN/IN
120.00
100.00
80.00
60.00
40.00
20.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST IN YEARS
TENSILE STRESS AT RUPTURE, 5 MOTOR COMPOSITE, STN AT 0.0002

FIGURE 5-4

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NO. SAMPLES
(57.0S)	11S
67.0	6
69.0	5
70.0	6
83.0	5
84.0	10
86.0	5
93.0	5
96.0	10
99.0	10
104.0	5
105.0	5
106.0	5
108.0	5
117.0	5
119.0	5
121.0	5
129.0	5
131.0	5
134.0	5
142.0	5
155.0	5

TENSILE MODULUS, 5 MOTOR COMPOSITE, STN RT 0.0002



TENSILE MODULUS, 5 MOTOR COMPOSITE, STN RT 0.0002

FIGURE 5-5

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR. SAMPLES
(70.05)	65
99.0	10
108.0	5
121.0	5
134.0	5

TENSILE STRAIN AT MAX STRESS, MOTOR # 0031064, STRN RT .0002

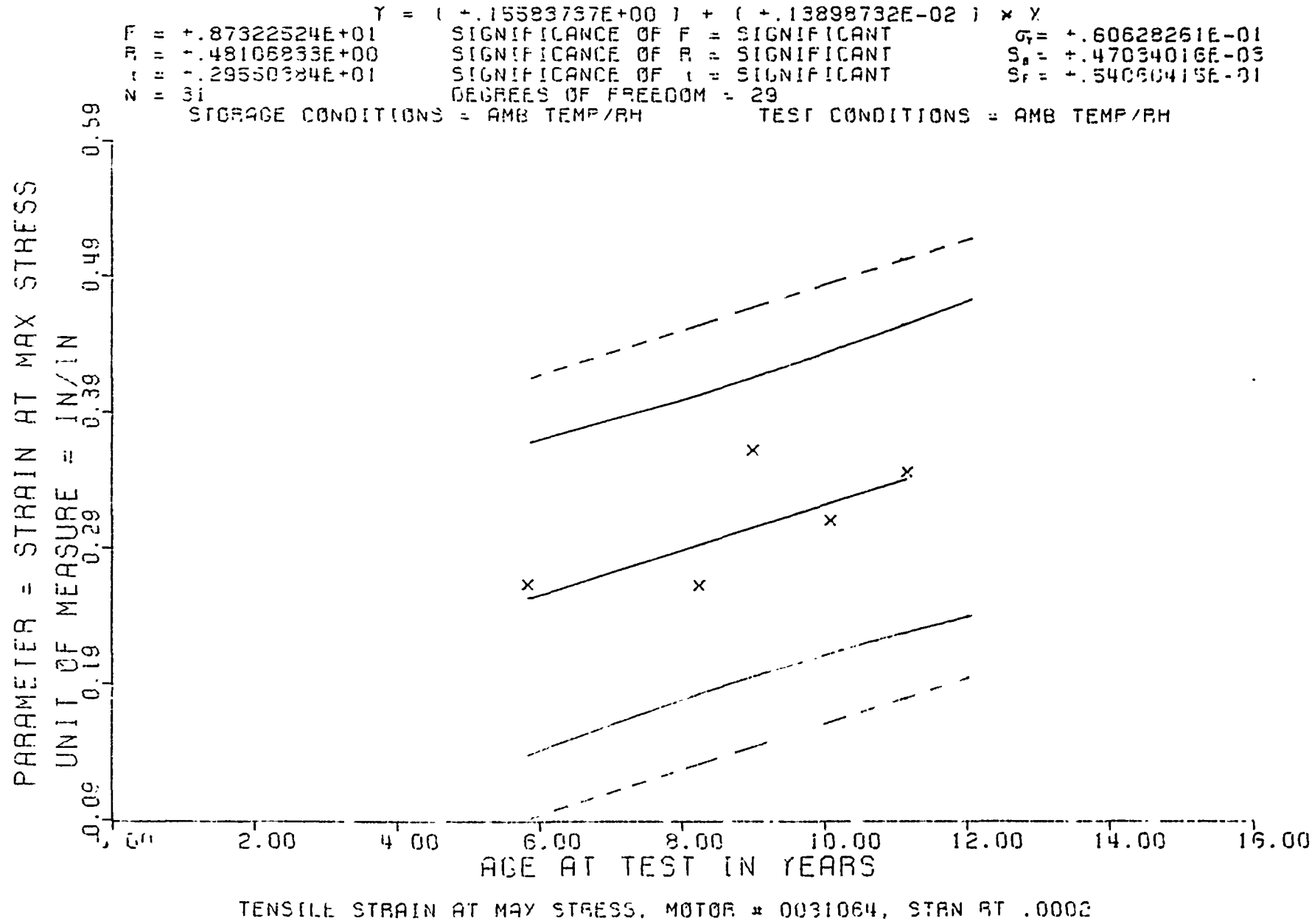

Y = (+.15583737E+00) + (+.13898732E-02) × X
F = +.87322524E+01 SIGNIFICANCE OF F = SIGNIFICANT σT = +.60628261E-01
R = +.48106833E+00 SIGNIFICANCE OF R = SIGNIFICANT Sa = +.47034016E-03
t = +.29550384E+01 SIGNIFICANCE OF t = SIGNIFICANT Sr = +.54066415E-01
N = 31 DEGREES OF FREEDOM = 29
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH
PARAMETER = STRAIN AT MAX STRESS
UNIT OF MEASURE = IN/IN
0.59
0.49
0.39
0.29
0.19
0.09
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST IN YEARS
TENSILE STRAIN AT MAX STRESS, MOTOR # 0031064, STRN RT .0002

FIGURE 5-6

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
(67.0S)	6S
96.0	10
105.0	5
117.0	5
131.0	5

TENSILE STRAIN AT MAX STRESS, MOTOR # 0031134, STRN RT .0002

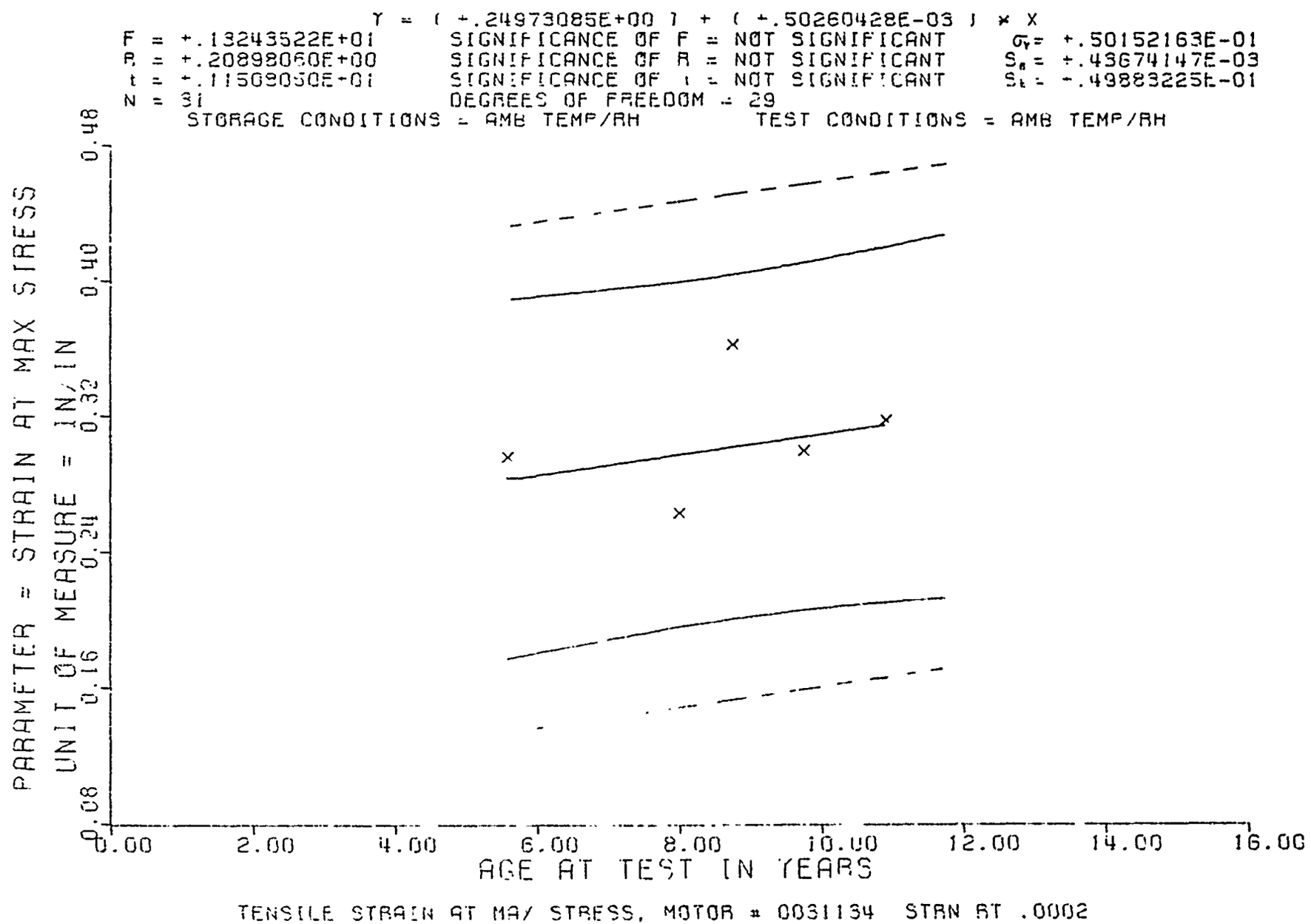

Y = (+.24973085E+00) + (+.50260428E-03) * X
F = +.13243522E+01 SIGNIFICANCE OF F = NOT SIGNIFICANT σY = +.50152163E-01
R = +.20898060E+00 SIGNIFICANCE OF R = NOT SIGNIFICANT Sa = +.43674147E-03
t = +.11509050E-01 SIGNIFICANCE OF t = NOT SIGNIFICANT St = +.49883225E-01
N = 31 DEGREES OF FREEDOM = 29
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH
PARAMETER = STRAIN AT MAX STRESS
UNIT OF MEASURE = IN/IN
0.08
0.16
0.24
0.32
0.40
0.48
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST IN YEARS
TENSILE STRAIN AT MAX STRESS, MOTOR # 0031134 STRN RT .0002

FIGURE 5-7

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
(57.05)	65
34.0	10
93.0	5
106.2	5
119.0	5

TENSILE STRAIN AT MAX STRESS, MOTOR # 0032434, STRN RT .0002

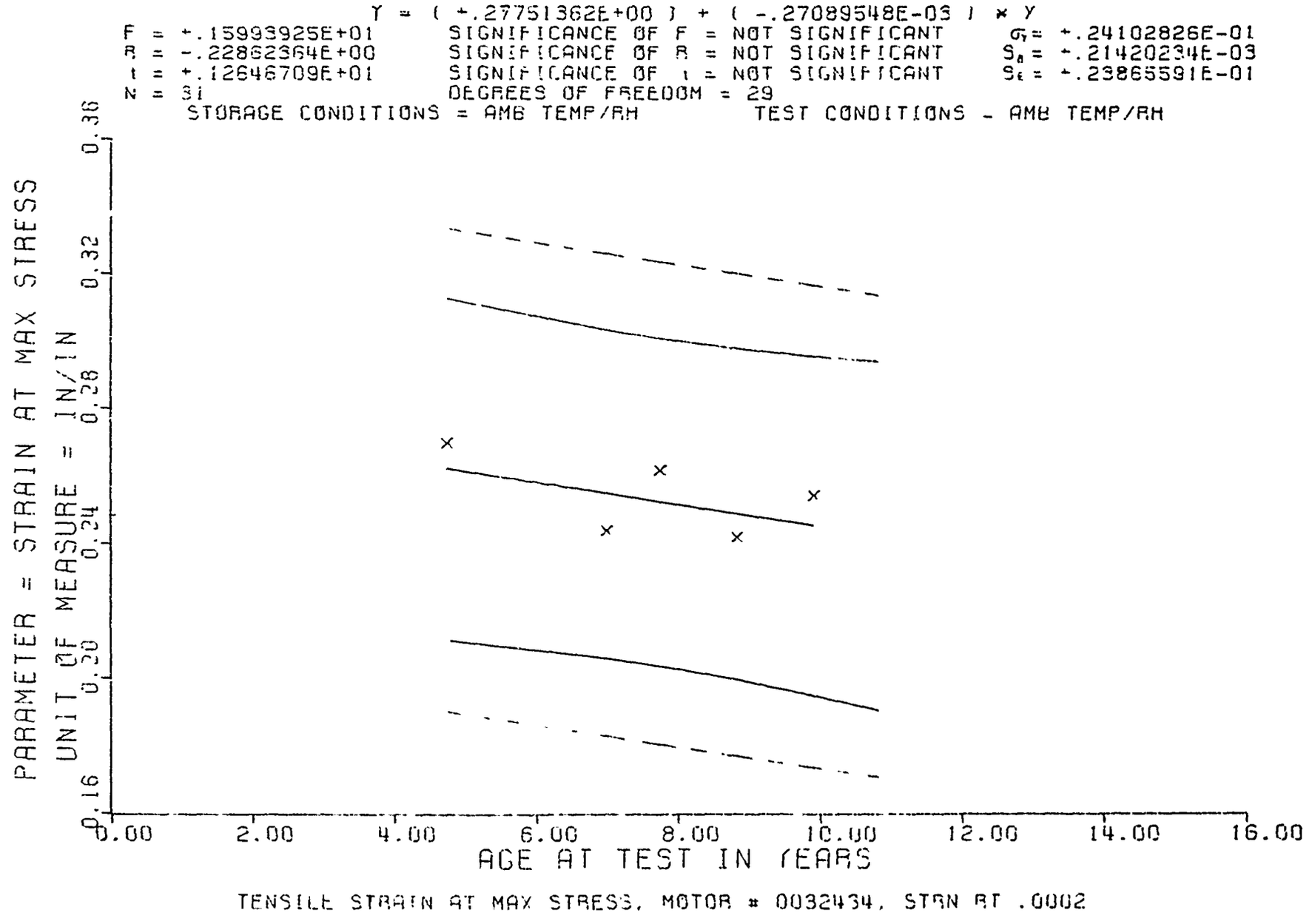
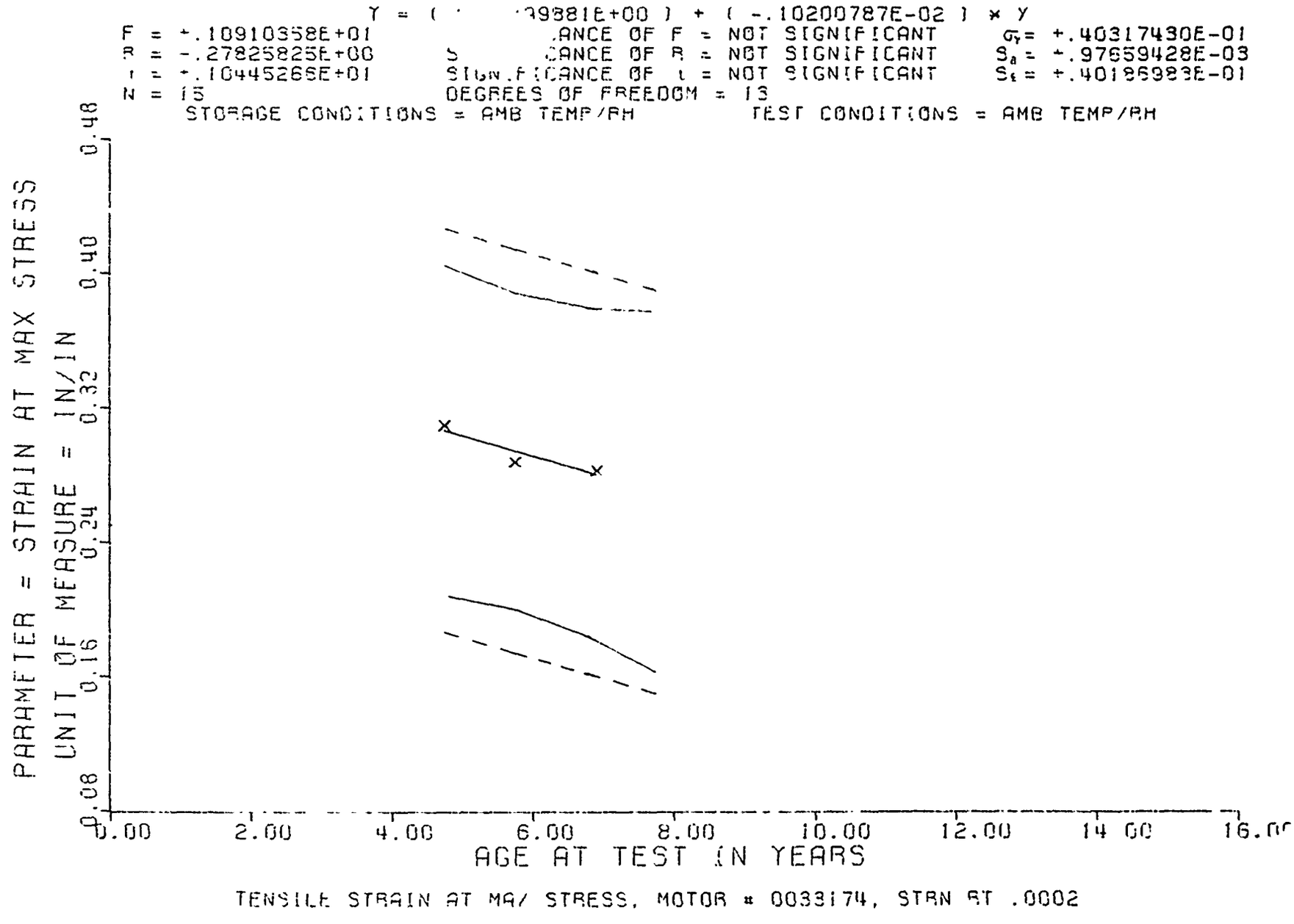

Y = (+.27751362E+00) + (-.27089548E-03) * Y
F = +.15993925E+01 SIGNIFICANCE OF F = NOT SIGNIFICANT σr = +.24102826E-01
R = -.22862364E+00 SIGNIFICANCE OF R = NOT SIGNIFICANT Sa = +.21420234E-03
t = +.12646709E+01 SIGNIFICANCE OF t = NOT SIGNIFICANT Se = +.23865591E-01
N = 31 DEGREES OF FREEDOM = 29
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS - AMB TEMP/RH
PARAMETER = STRAIN AT MAX STRESS
UNIT OF MEASURE = IN/IN
0.36
0.32
0.28
0.24
0.20
0.16
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST IN YEARS
TENSILE STRAIN AT MAX STRESS, MOTOR # 0032434, STRN RT .0002

FIGURE 5-8

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
(57.05)	55
69.0	5
93.0	5

TENSILE STRAIN AT MAX STRESS, MOTOR # 0033174, STRN RT .0002



TENSILE STRAIN AT MAX STRESS, MOTOR # 0033174, STRN RT .0002

FIGURE 5-9

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NO. SAMPLES
(86.0S)	5S
104.0	5
129.0	5
142.0	5
155.0	5

TENSILE STRAIN AT MAX STRESS, MOTOR # GOOK131, STRN RT .0002

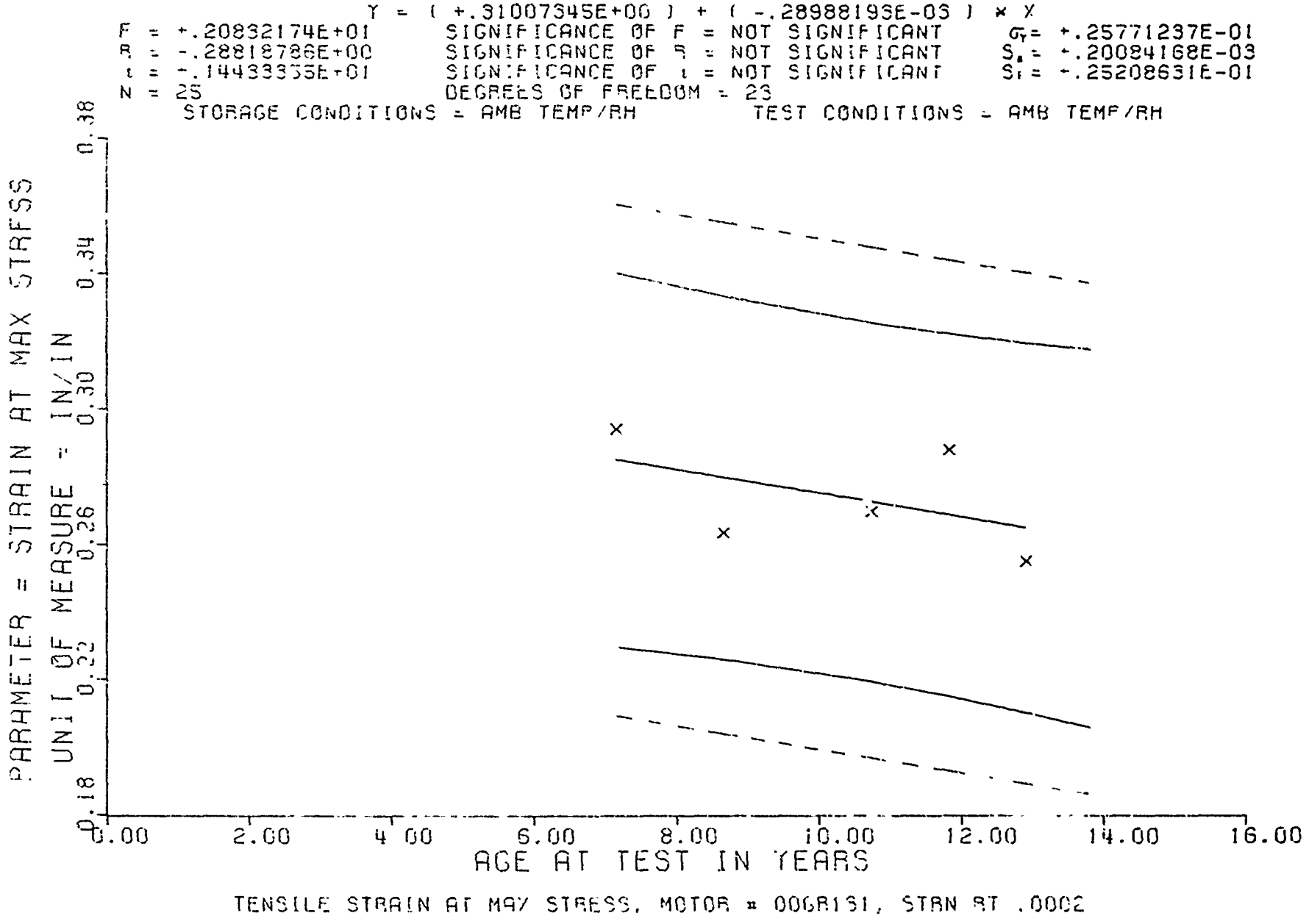

Y = (+.31007345E+00) + (-.28988195E-03) * X
F = +.20832174E+01 SIGNIFICANCE OF F = NOT SIGNIFICANT σY = +.25771237E-01
R = -.28818786E+00 SIGNIFICANCE OF R = NOT SIGNIFICANT Sa = +.20084168E-03
t = -.14433355E+01 SIGNIFICANCE OF t = NOT SIGNIFICANT Sr = +.25208631E-01
N = 25 DEGREES OF FREEDOM = 23
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH
PARAMETER = STRAIN AT MAX STRESS
UNIT OF MEASURE = IN/IN
0.18
0.22
0.26
0.30
0.34
0.38
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST IN YEARS
TENSILE STRAIN AT MAX STRESS, MOTOR = 006R1S1, STRN RT .0002

FIGURE 5-10

TABLE 5-1

EFFECT OF HUMIDITY ON TEST DATA

Motor Nr	Humidity	em	Sm	er	Sr	G
0031064	50	.377	67.00	.381	57.56	518
	50	.384	69.59	.411	55.98	480
	20	.286	69.50	.294	66.30	501
	20	.360	69.90	.376	66.30	511
	20	.326	71.00	.330	68.60	490
0031134	50	.343	65.66	.363	54.78	532
	50	.304	63.03	.353	53.06	490
	20	.336	70.20	.344	65.10	540
	20	.300	70.60	.308	67.80	555
	20	.308	72.50	.320	68.70	523
0032434	50	.246	65.70	.300	53.90	604
	50	.244	64.26	.292	53.27	630
	20	.268	72.30	.278	68.90	672
	20	.244	74.00	.260	60.60	655
	20	.270	72.50	.280	56.50	693
0033174	50	.252	56.68	.327	47.70	531
	50	.256	58.25	.318	48.49	560
	20	.300	65.00	.306	62.70	544
	20	.292	63.10	.298	61.60	490
	20	.316	62.70	.322	58.20	511
Gr 131	50	.268	63.25	.302	52.70	595
	50	.276	67.37	.292	57.61	613
	20	.254	71.20	.266	69.50	608
	20	.228	67.40	.230	61.20	608
	20	.250	70.60	.258	67.60	554

SECTION VI

LOW RATE BIAXIAL

A 3/4" GL rail specimen, 3/16" thick is used for this test. The specimens are tested on the Instron Tensile Tester at a crosshead speed of 0.2 in/min (strain rate of .1143 in/in/min).

Strains for the five motor composite show a significant increase while the stresses do not show a significant change (Figure 6-1 through 6-4). Modulus shows a significant decrease (Figure 6-5). However, there was only one data point available for each motor for 1972 and 1973. The regression analyses was conducted using this limited data base inorder to satisfy Service Engineerings' requirements to establish an aging trend for this test, recognizing that the validity was compromised by the limited sampling.

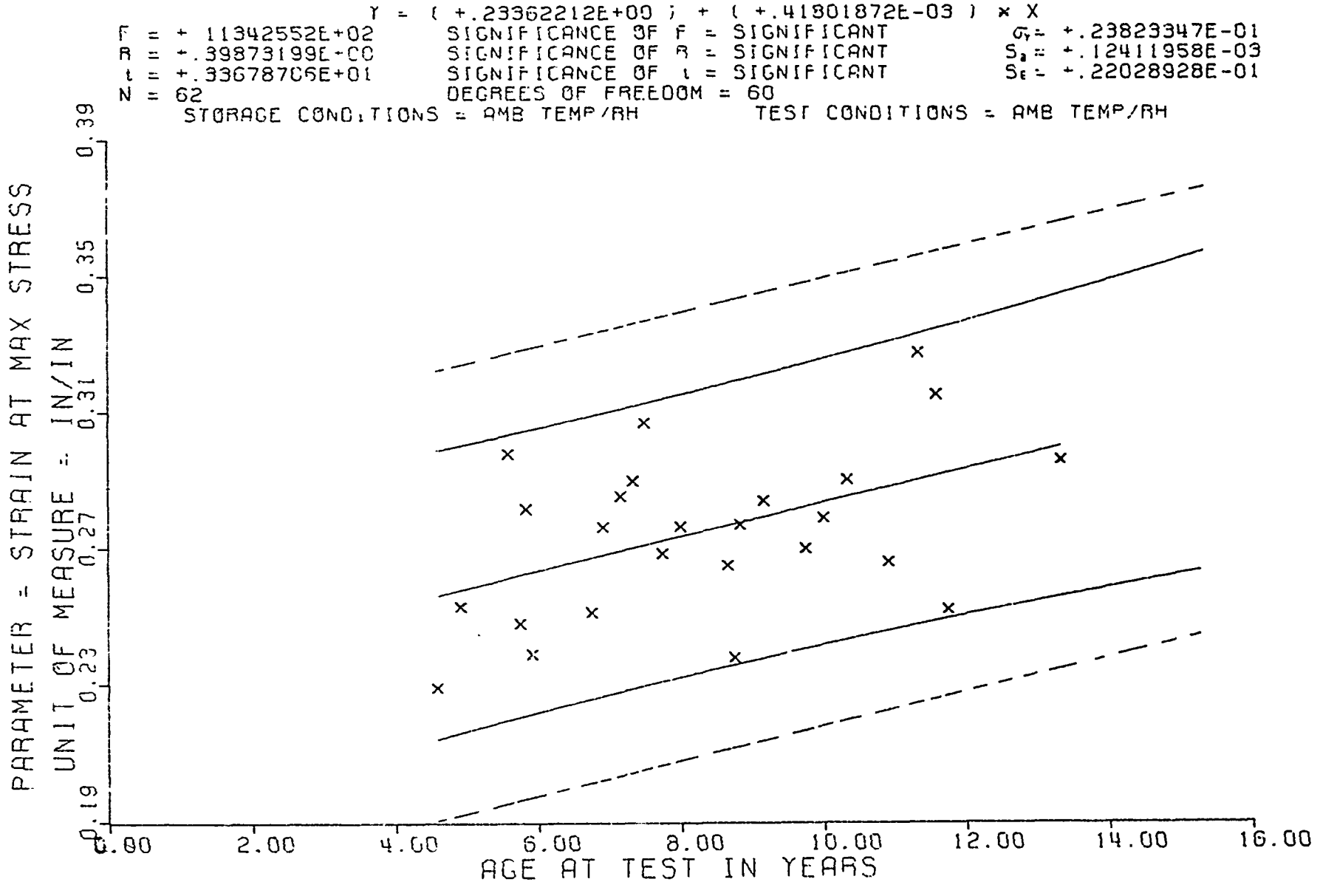
The significant increase in strain is probably due to long storage after cutting. For the three motors first tested in 1968, the strains are now approximately 11% higher than in 1968. The stress data do not show a consistent increase.

Strain at maximum stress for Motors 0031064 and 0031434 shows a significant increase (Figures 6-6 and 6-8). There is no significant change for the other motors (Figures 6-7, 6-9 and 6-10).

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
55.0	4
59.0	2
67.0	4
69.0	1
70.0	4
71.0	3
81.0	6
83.0	3
86.0	3
88.0	1
90.0	2
93.0	6
96.0	8
104.0	2
105.0	1
106.0	2
110.0	2
117.0	1
120.0	1
124.0	1
131.0	1
136.0	1
139.0	1
141.0	1
160.0	1

TENSILE STRAIN AT MAX STRESS, 5 MOTOR COMPOSITE, STN RT 0.2



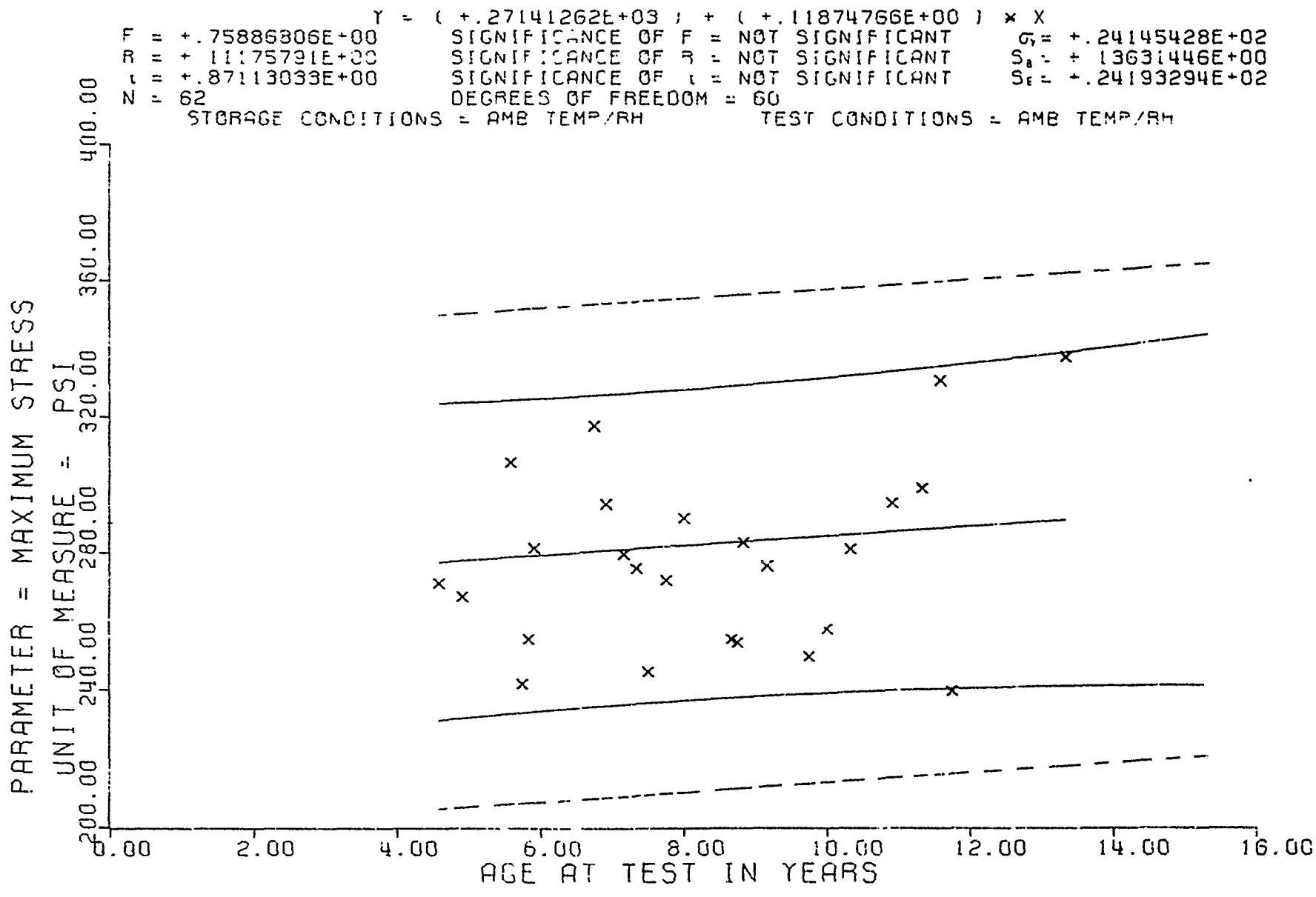
TENSILE STRAIN AT MAX STRESS, S MOTOR COMPOSITE, STN RT 0.2

FIGURE 6-1

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
55.0	4
59.0	2
67.0	4
69.0	1
70.0	4
71.0	3
81.0	6
83.0	3
86.0	3
88.0	1
90.0	2
93.0	6
96.0	8
104.0	2
105.0	1
106.0	2
110.0	2
117.0	1
120.0	1
124.0	1
131.0	1
136.0	1
139.0	1
141.0	1
160.0	1

TENSILE MAXIMUM STRESS, 5 MOTOR COMPOSITE, STN RT 0.2



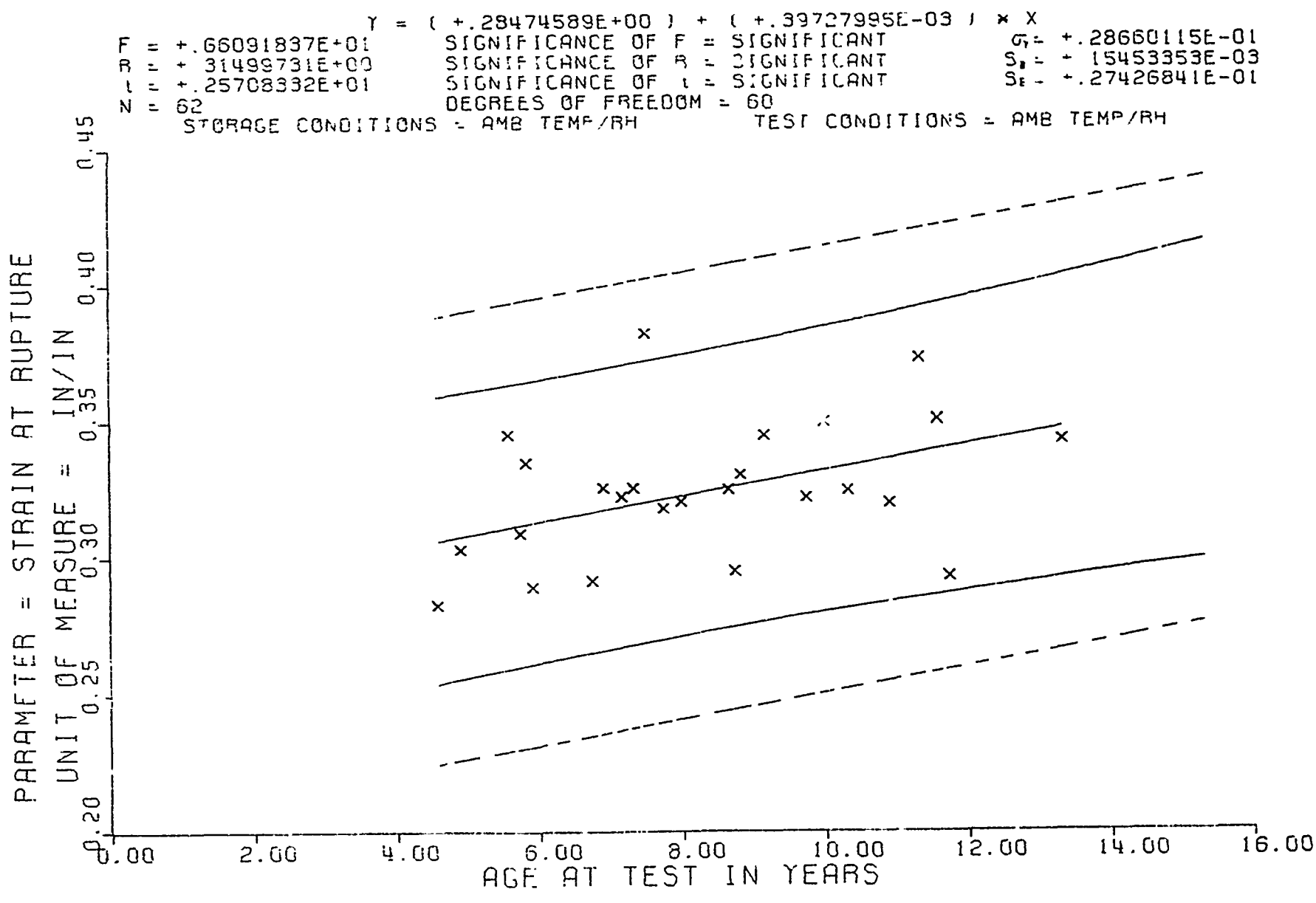
TENSILE MAXIMUM STRESS, S MOTOR COMPOSITE, STN RT 0.2

FIGURE 6-2

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
55.0	4
59.0	2
67.0	1
69.0	1
70.0	4
71.0	3
81.0	6
83.0	3
86.0	3
88.0	1
90.0	2
93.0	6
96.0	8
104.0	2
105.0	1
106.0	2
110.0	2
117.0	1
120.0	1
124.0	1
131.0	1
136.0	1
139.0	1
141.0	1
160.0	1

TENSILE STRAIN AT RUPTURE, 5 MOTOR COMPOSITE, STN RT 0.2



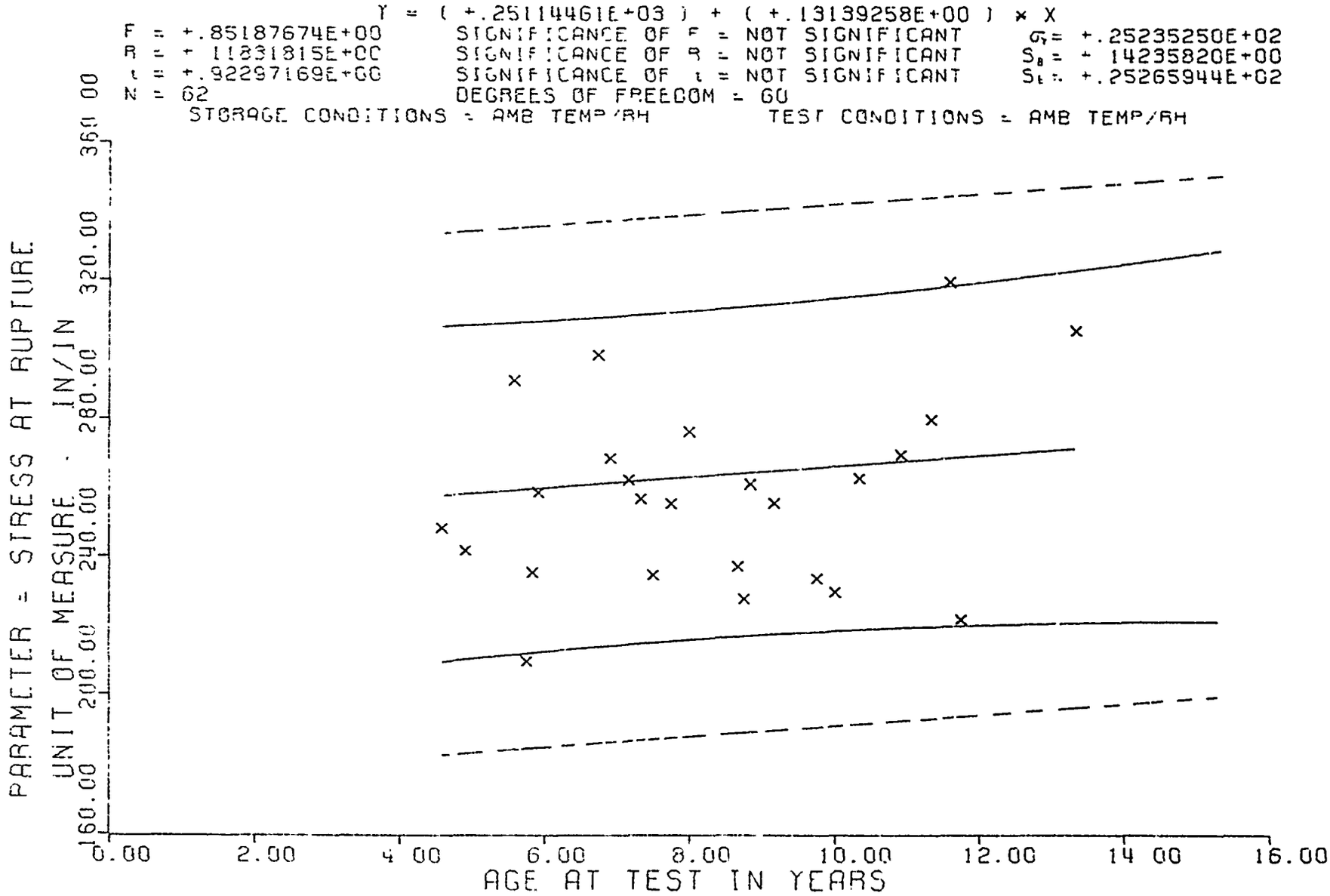
TENSILL STRAIN AT RUPTURE, 5 MOTOR COMPOSITE, STN RT 0.2

FIGURE 6-3

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
55.0	4
59.0	2
67.0	4
69.0	1
70.0	4
71.0	3
81.0	6
83.0	3
86.0	3
88.0	1
90.0	2
93.0	6
96.0	8
104.0	2
105.0	1
106.0	2
110.0	2
117.0	1
120.0	1
124.0	1
131.0	1
136.0	1
139.0	1
141.0	1
160.0	1

TENSILE STRESS AT RUPTURE, 5 MOTOR COMPOSITE, STN RT 0.2



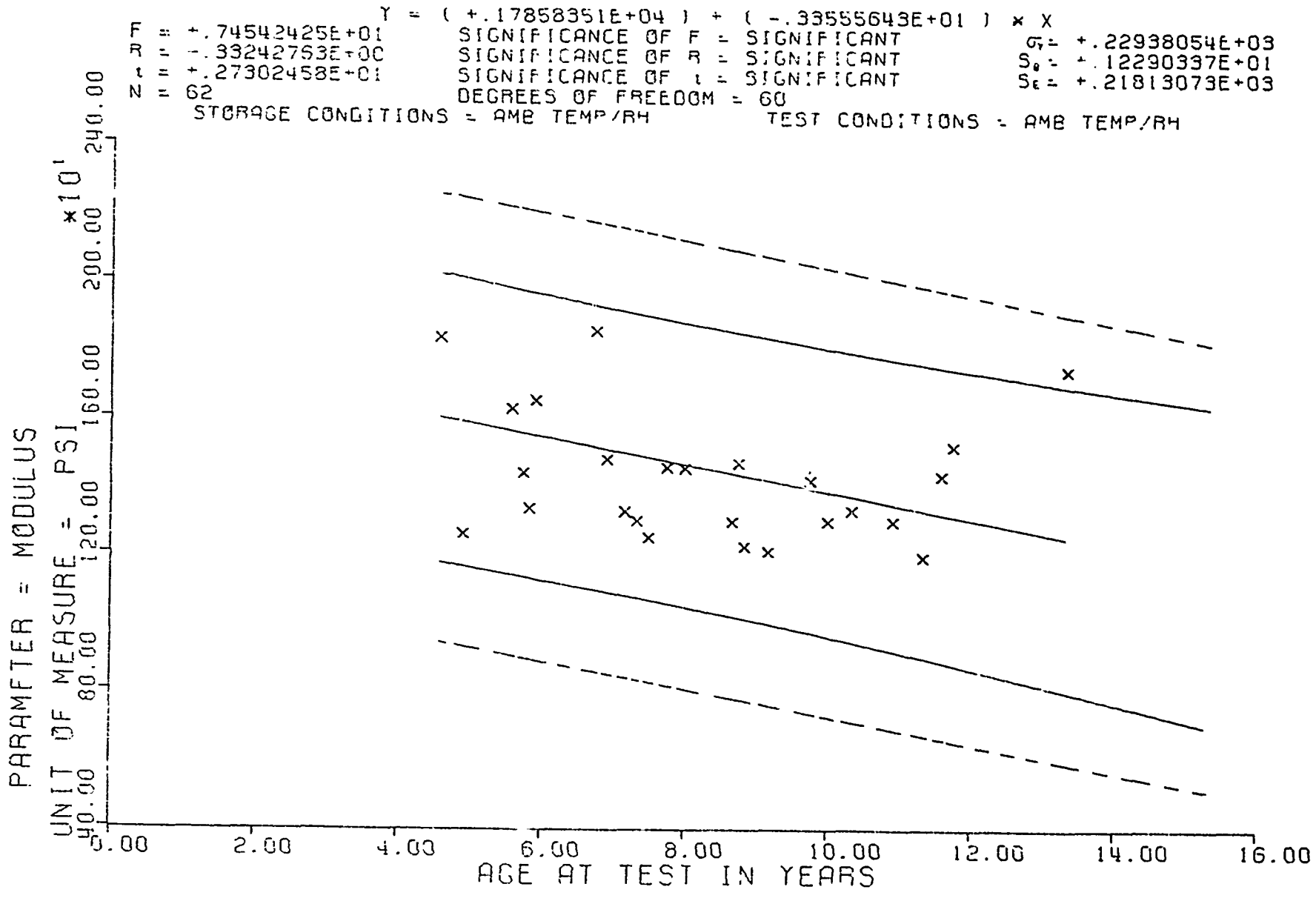
TENSILE STRESS AT RUPTURE, 5 MOTOR COMPOSITE, STN RT 0.2

FIGURE 6-4

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
55.0	4
59.0	2
67.0	4
69.0	1
70.0	4
71.0	3
81.0	6
83.0	3
86.0	3
88.0	1
90.0	2
93.0	6
96.0	8
104.0	2
105.0	1
106.0	2
110.0	2
117.0	1
120.0	1
124.0	1
131.0	1
136.0	1
139.0	1
141.0	1
160.0	1

TENSILE MODULUS, 5 MOTOR COMPOSITE, STN RT 0.2



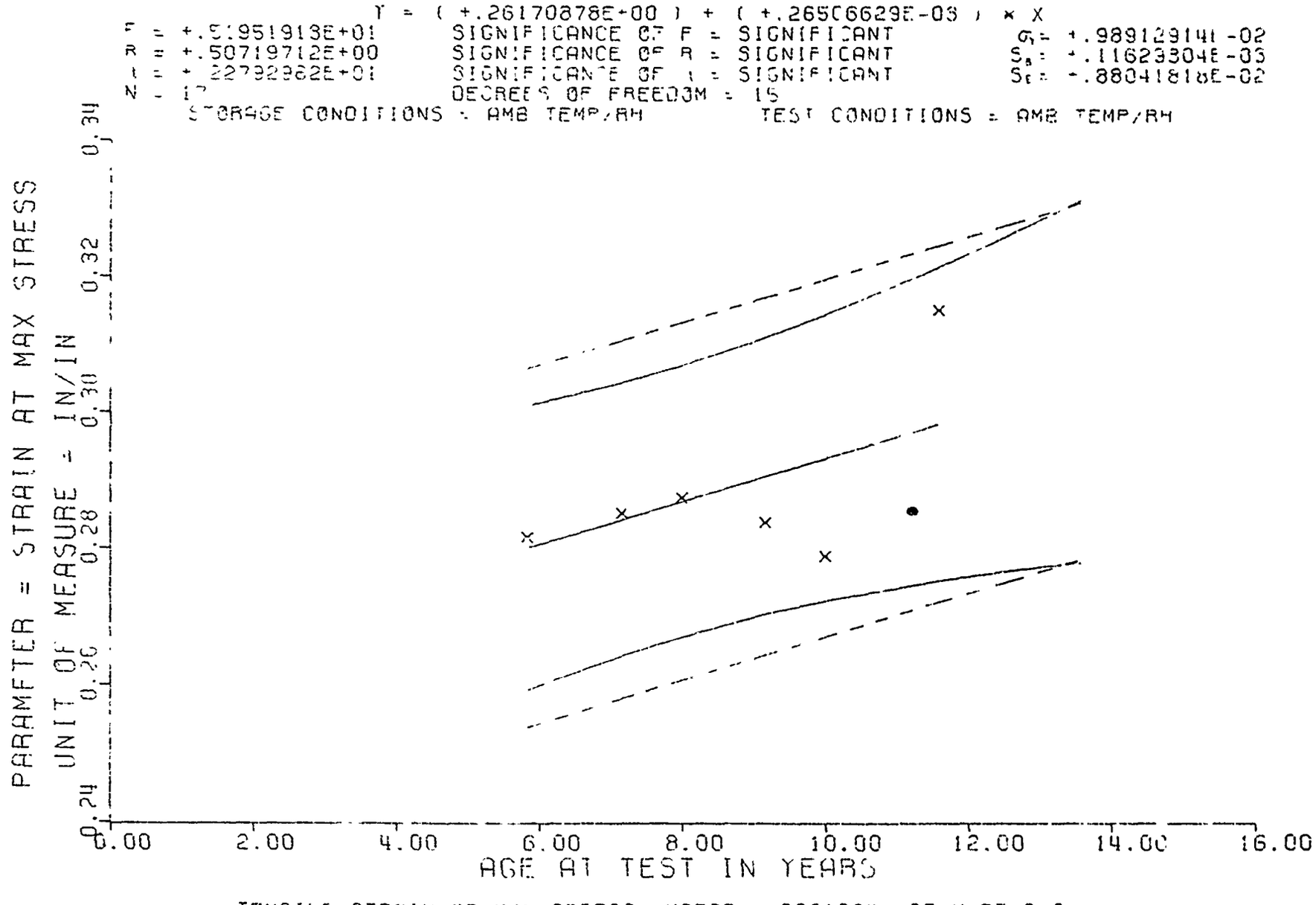
TENSILE MODULUS, 5 MOTOR COMPOSITE, STN RT 0.2

FIGURE 6-5

*** SAMPLE SIZE SUMMARY ***

(METALS)	SAMPLES
70.0	4
80.0	3
90.0	6
100.0	2
120.0	1
130.0	1

TENSILE STRAIN AT MAX STRESS, MOTOR # C021064, STRN RT 0.2



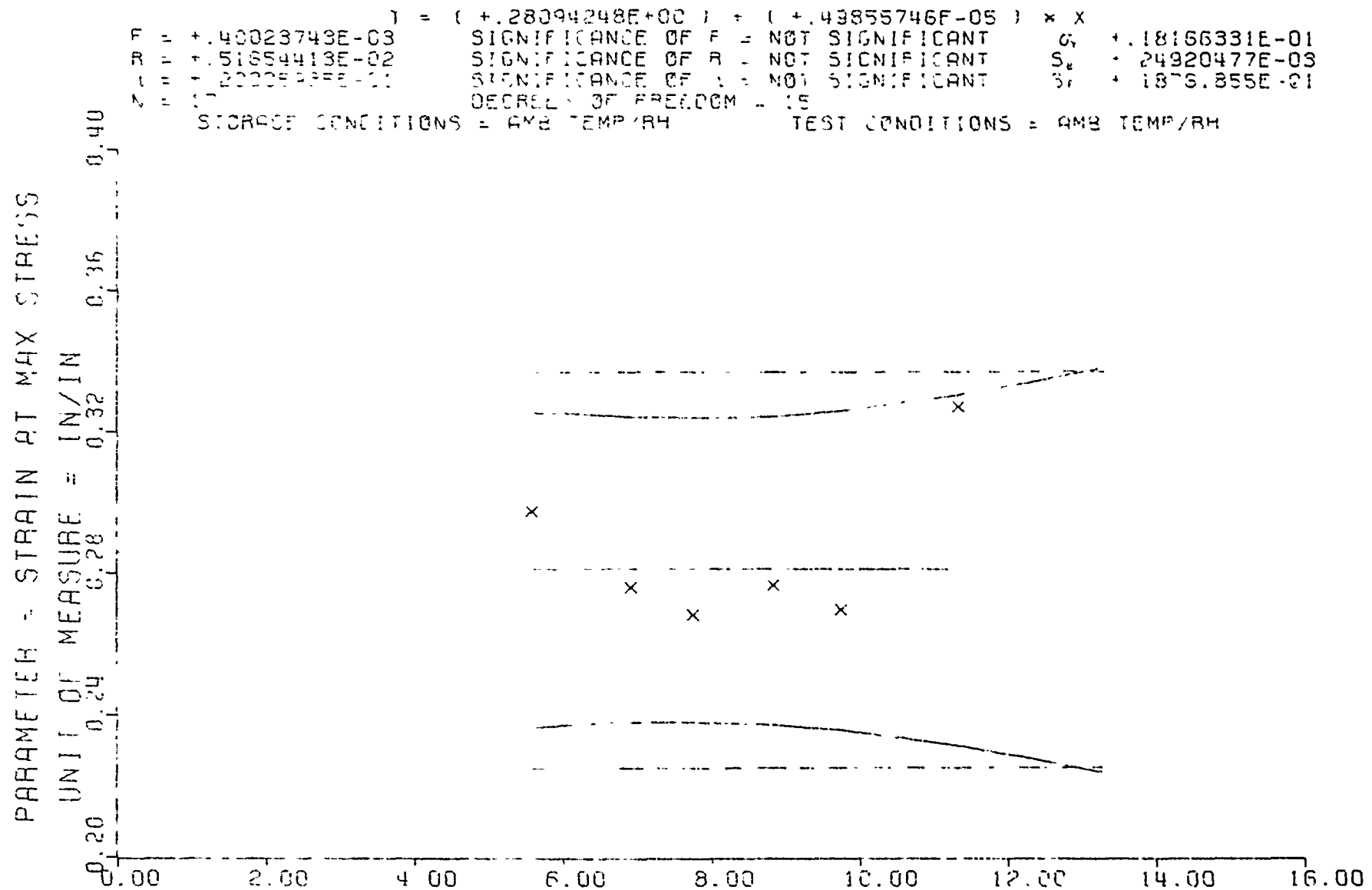
TENSILE STRAIN AT MAX STRESS, MOTOR # 0031064, STRAIN RT 0.2

FIGURE 6-6

*** SAMPLE SIZE SUMMARY ***

(MONTHS)	SAMPLES
67.0	4
83.	3
93.	6
106.0	2
117.0	1
136.0	1

TENSILE STRAIN AT MAX STRESS, MUTOR # 0021134, STRN RT 0.2



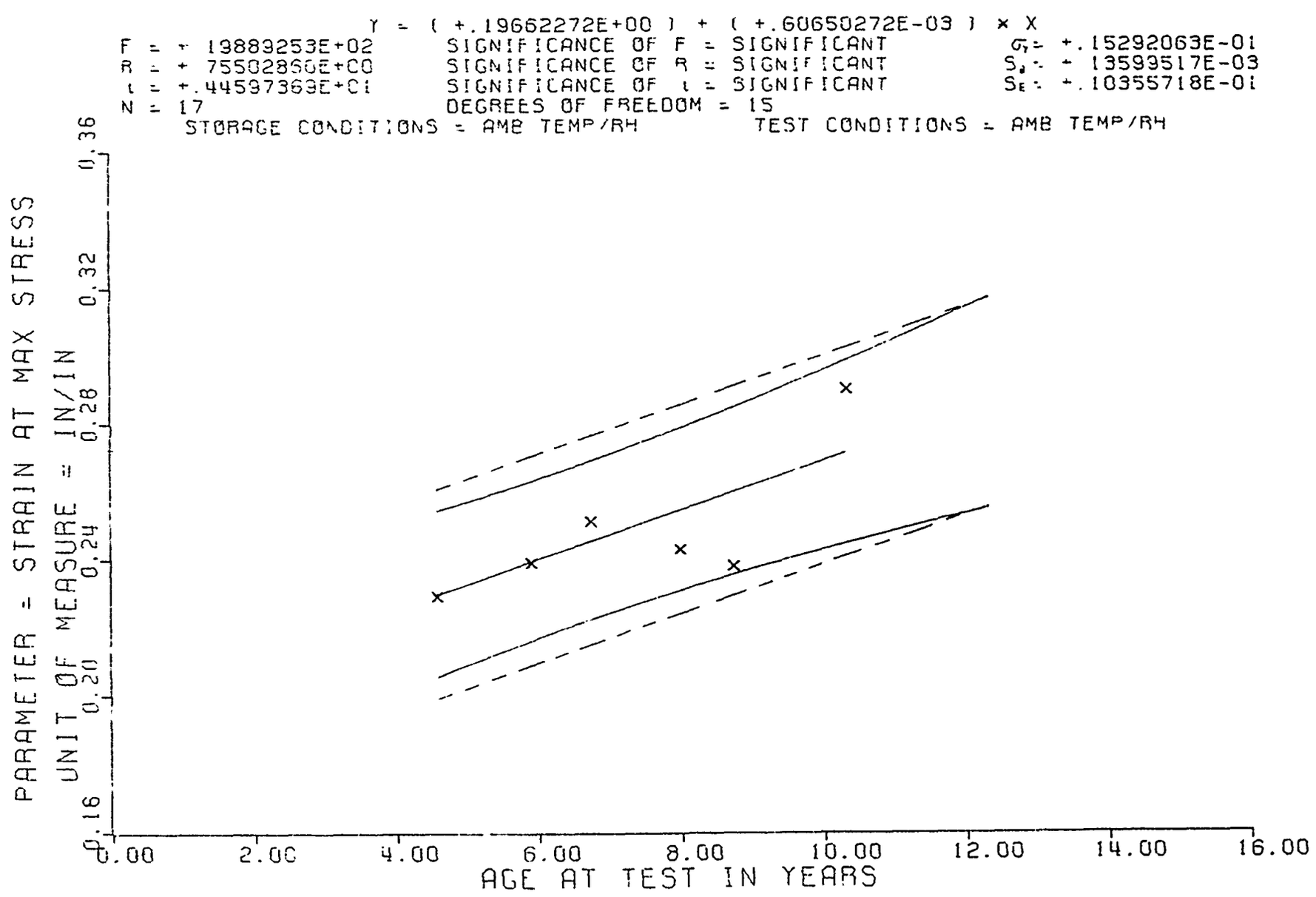
TENSILE STRAIN AT MAX STRESS, MOTOR = 0031134, STRN RT 0.2

FIGURE 6-7

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
55.0	4
71.0	3
81.0	6
96.0	2
105.0	1
124.0	1

TENSILE STRAIN AT MAX STRESS, MOTOR # C032434, STRN RT 0.2



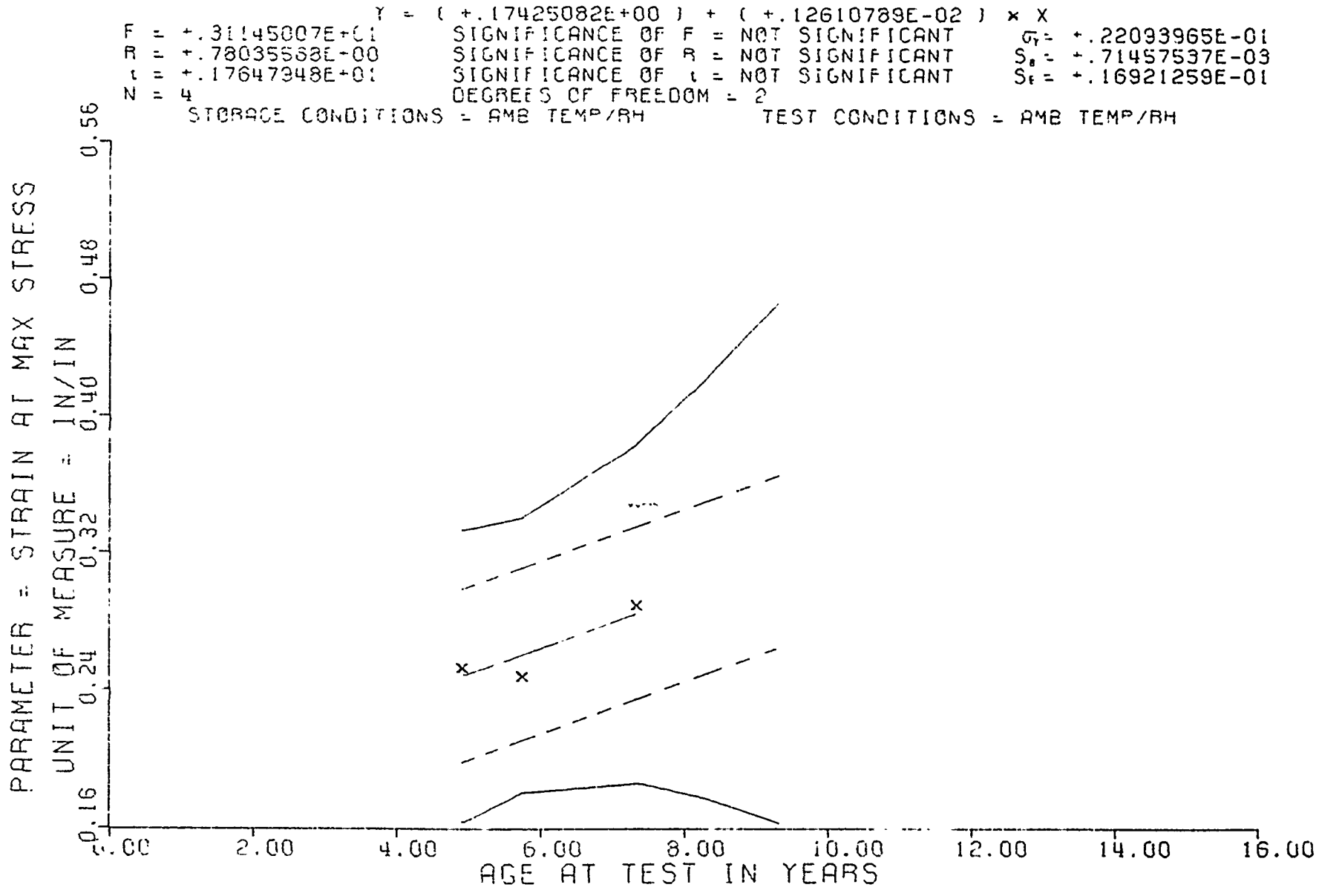
TENSILE STRAIN AT MAX STRESS, MOTOR = 0032434, STRN RT 0.2

FIGURE 6-8

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
59.0	2
69.0	1
88.0	1

TENSILE STRAIN AT MAX STRESS, MOTOR # 0033174, STRN RT 0.2



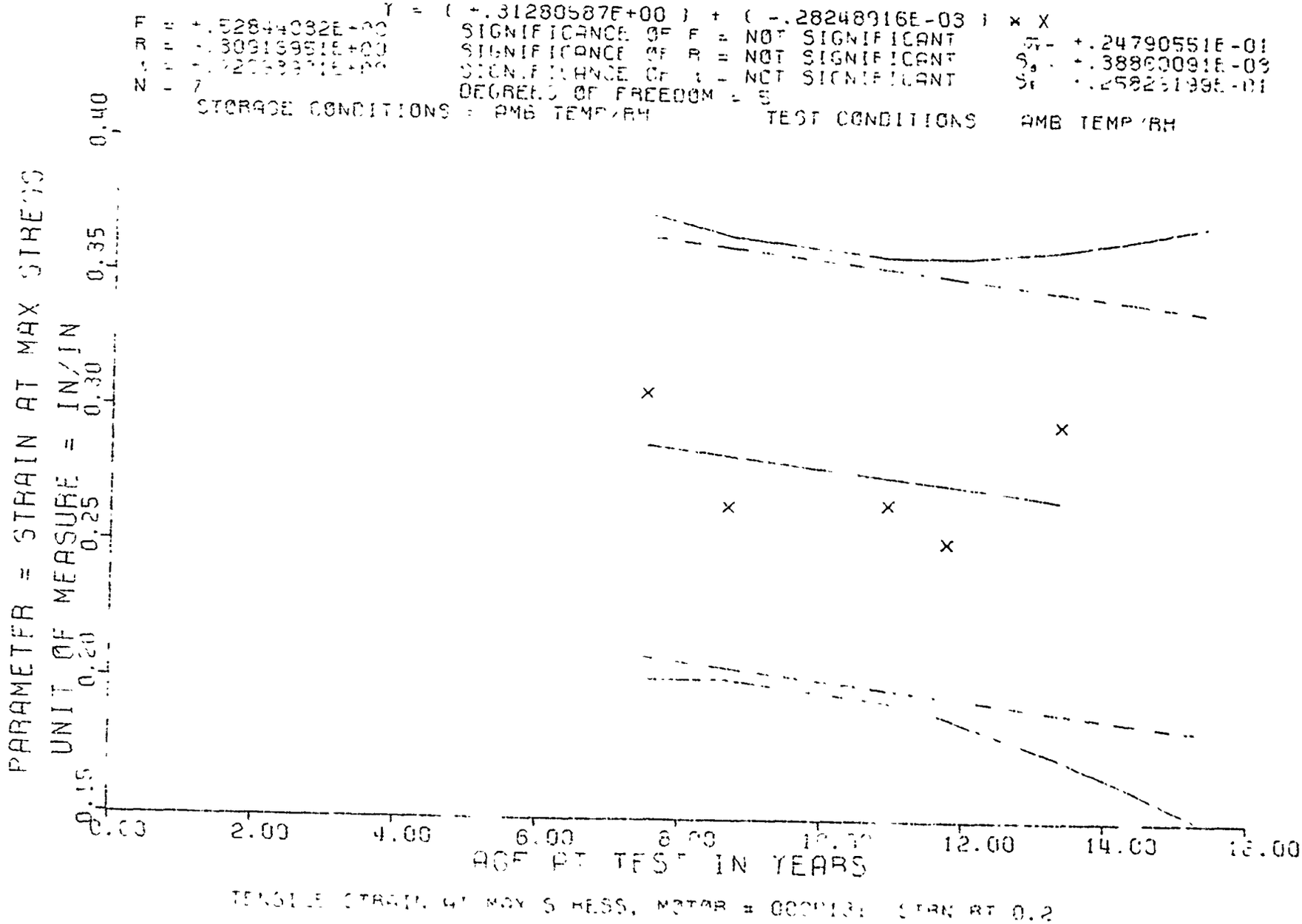
TENSILE STRAIN AT MAX STRESS, MOTOR # 0033174, STRN RT 0.2

FIGURE 6-9

*** SAMPLE-SIZE-SUMMARY ***

AGE (MONTHS)	NO. SAMPLES
96.0	2
104.0	2
131.0	1
141.0	1
160.0	1

TENSILE STRAIN AT MAX STRESS; MOTOR # COGK131, STAN RT-0.2



TENSILE STRAIN AT MAX STRESS, MATAB = 80°F/RH STRN RT 0.2

FIGURE 6-10

SECTION VII

HIGH RATE TRIAXIAL

A 3/4" GL rail specimen, 3/16" thick is used for this test. The specimens are tested on the Plastechon at a crosshead speed of 1750 in/min under 300 psi N_2.

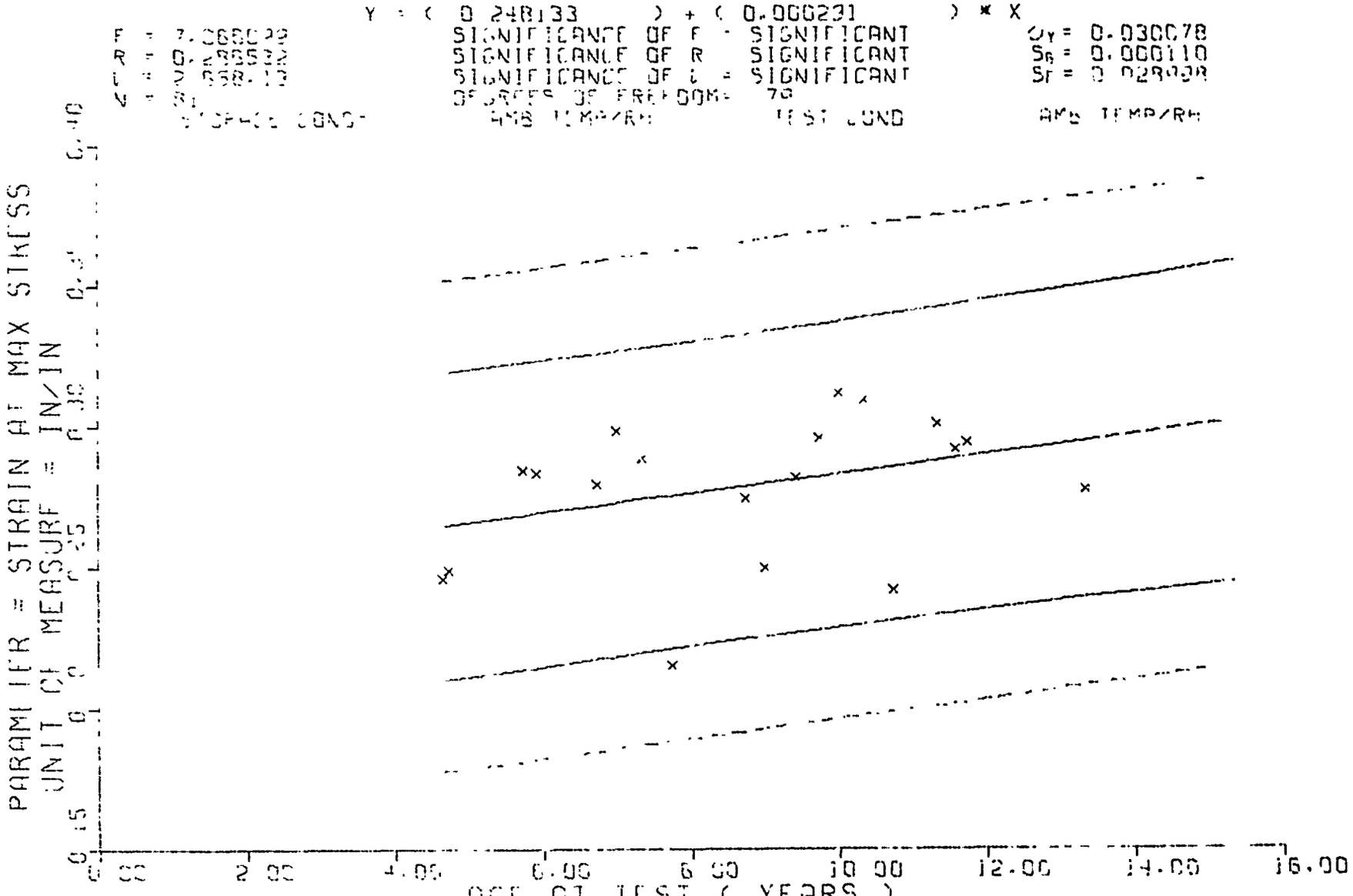
Strains for the five motor composite show a significant increase (Figures 7-1 and 7-3). Maximum stress does not show a significant increase (Figure 7-2) but stress at rupture does show a significant increase (Figure 7-4). Modulus does not show a significant decrease (Figure 7-5).

Three of the five motors do not show a significant increase in strain at maximum stress (Figures 7-6, 7-7 and 7-10). Both motors 32434 and 33174 do show a significant increase in this parameter (Figures 7-8 and 7-9).

SAMPLE SIZE SUMMARY

AGE (MONTHS)	NR SAMPLES
56.0	5
57.0	8
69.0	8
71.0	4
81.0	6
84.0	6
88.0	3
93.0	3
105.0	9
108.0	3
113.0	2
117.0	3
120.0	3
124.0	3
129.0	3
136.0	3
139.0	3
141.0	3
160.0	3

STRAIN AT MAX STRESS, 1750 IN/MIN TRIAXIAL TENSILE AT 300 PSI, 5 MOTOR COMPOSITE



STRAIN AT MAX STRESS, 1750 IN/MIN TRIAXIAL TENSILE AT 350 PSI, 5 MOTOR COMPOSITE

FIGURE 7-1

SAMPLE SIZE SUMMARY

AGE (MONTHS)	NR SAMPLES
56.0	5
57.0	8
69.0	8
71.0	4
81.0	6
84.0	6
88.0	3
93.0	3
105.0	9
108.0	3
113.0	2
117.0	3
120.0	3
124.0	3
129.0	3
136.0	3
139.0	3
141.0	3
160.0	3

MAXIMUM STRESS, 1750 IN/MIN TRIAXIAL TENSILE AT 300 PSI, 5 MOTOR COMPOSITE

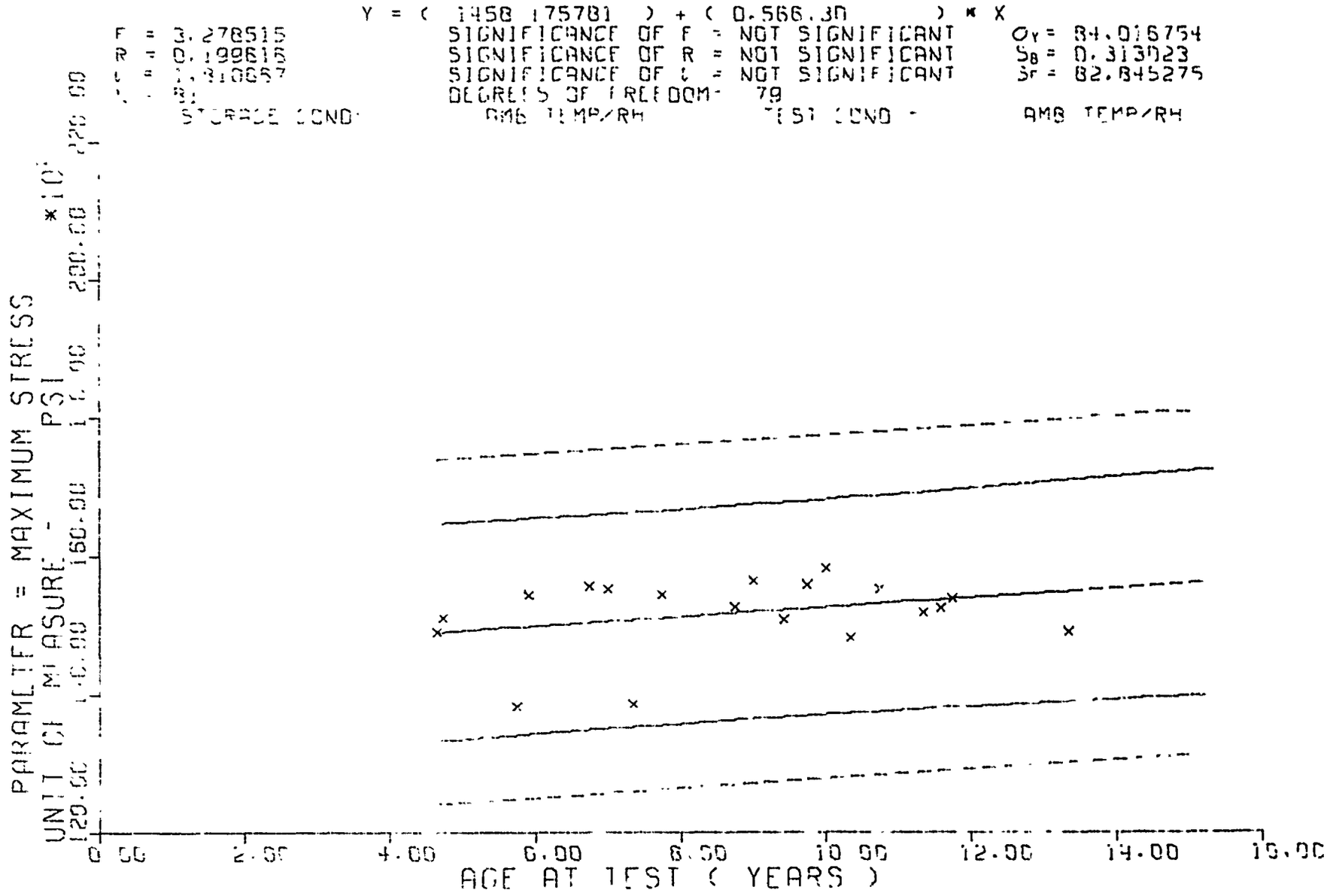

Y = (1458.175781) + (0.566.30) * X
F = 3.278515
R = 0.199616
SIGNIFICANCE OF F = NOT SIGNIFICANT
SIGNIFICANCE OF R = NOT SIGNIFICANT
SIGNIFICANCE OF t = NOT SIGNIFICANT
DEGREES OF FREEDOM= 79
σY = 84.016754
SB = 0.313023
Sr = 82.845275
STORAGE COND
AMB TEMP/RH
TEST COND -
AMB TEMP/RH
PARAMETER = MAXIMUM STRESS
UNIT OF MEASURE - PSI
*10
120.00
160.00
200.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST (YEARS)
MAXIMUM STRESS, 1750 IN/MIN TRIAXIAL TENSILE AT 300 PSI, 5 MOTOR COMPOSITE

FIGURE 7-2

SAMPLE SIZE SUMMARY

AGE (MONTHS)	NR SAMPLES
56.0	5
57.0	8
69.0	8
71.0	4
81.0	6
84.0	6
88.0	3
93.0	3
105.0	9
108.0	3
113.0	2
117.0	3
120.0	3
124.0	3
129.0	3
136.0	3
139.0	3
141.0	3
160.0	3

STRAIN AT RUPTURE, 1750 IN/MIN TRIAXIAL TENSILE AT 300 PSI, 5 MOTOR COMPOSITE

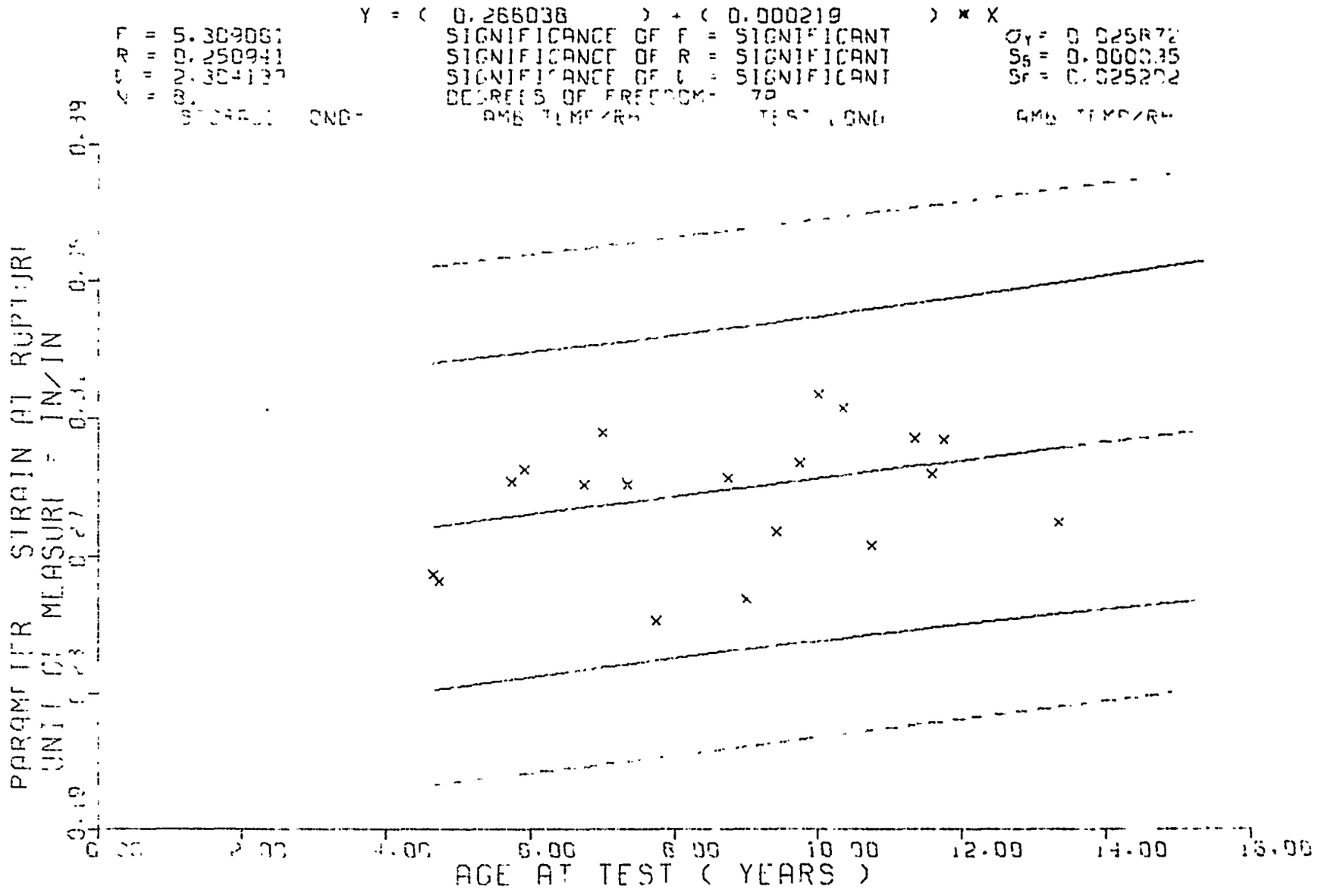
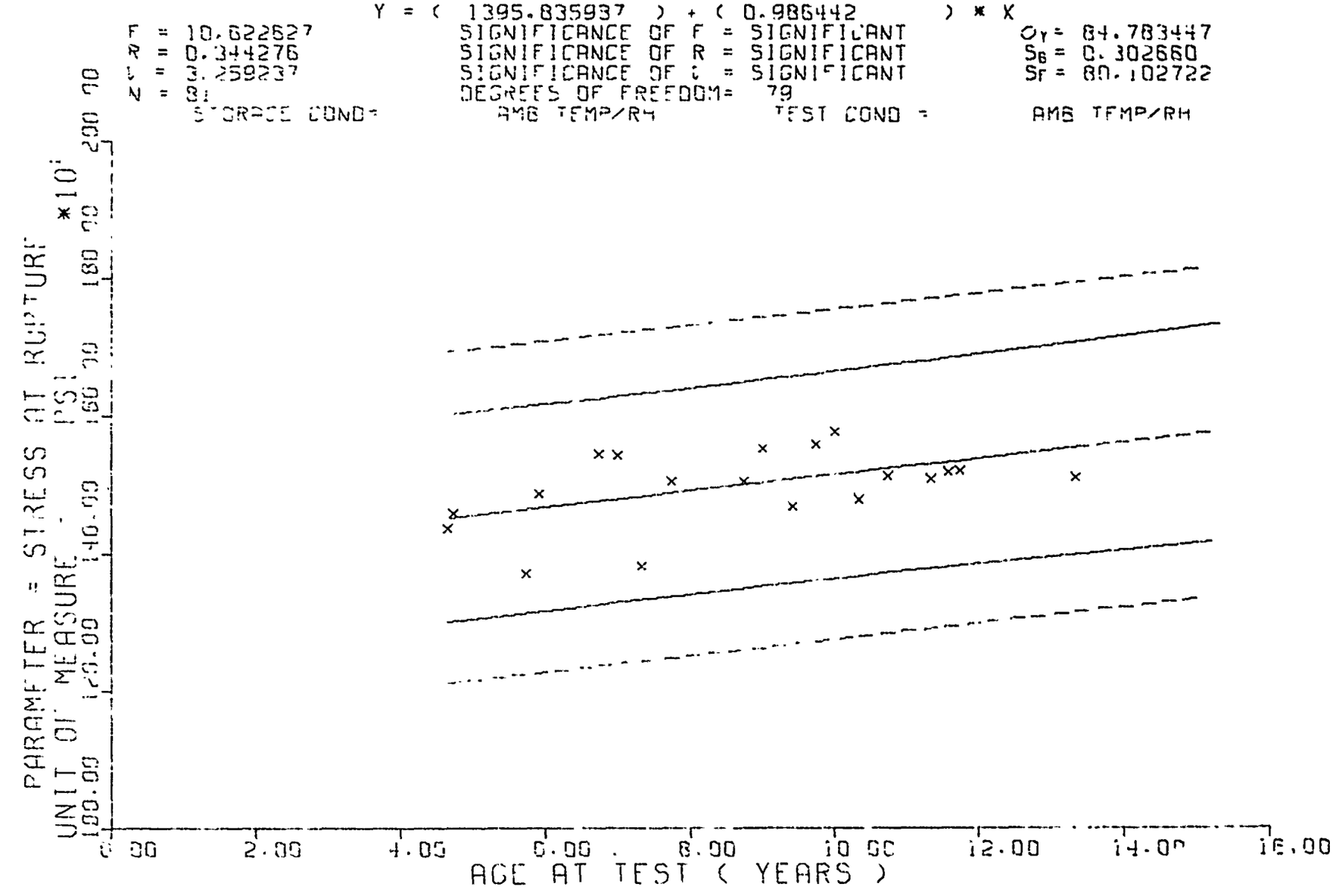

Y = (0.266038) + (0.000219) * X
F = 5.309061
R = 0.250941
SIGNIFICANCE OF F = SIGNIFICANT
SIGNIFICANCE OF R = SIGNIFICANT
DEGREES OF FREEDOM= 79
PARAMETER STRAIN AT RUPTURE
UNIT OF MEASURE = IN/IN
0.39
0.19
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST (YEARS)
STRAIN AT RUPTURE, 1750 IN/MIN TRIAXIAL TENSILE AT 300 PSI, 5 MOTOR COMPOSITE

FIGURE 7-3

SAMPLE SIZE SUMMARY

AGE (MONTHS)	NR SAMPLES
56.0	5
57.0	6
69.0	8
71.0	4
81.0	6
84.0	6
88.0	3
93.0	3
105.0	9
108.0	3
113.0	2
117.0	3
120.0	3
124.0	3
129.0	3
136.0	3
139.0	3
141.0	3
160.0	3

STRESS AT RUPTURE, 1750 IN/MIN TRIAXIAL TENSILE AT 300 PSI, 5 MOTOR COMPOSITE



STRESS AT RUPTURE, 1750 IN/MIN TRIAXIAL TENSILE AT 300 PSI, 5 MOTOR COMPOSITE

FIGURE 7-4

SAMPLE SIZE SUMMARY

AGE (MONTHS)	NR SAMPLES
56.0	5
57.0	8
69.0	8
71.0	4
81.0	6
84.0	6
88.0	3
93.0	3
105.0	9
108.0	3
113.0	2
117.0	3
120.0	3
124.0	3
129.0	3
136.0	3
139.0	3
141.0	3
160.0	3

MODULUS, 1750 IN/MIN TRIAXIAL TENSILE AT 300 PSI, 5 MOTOR COMPOSITE

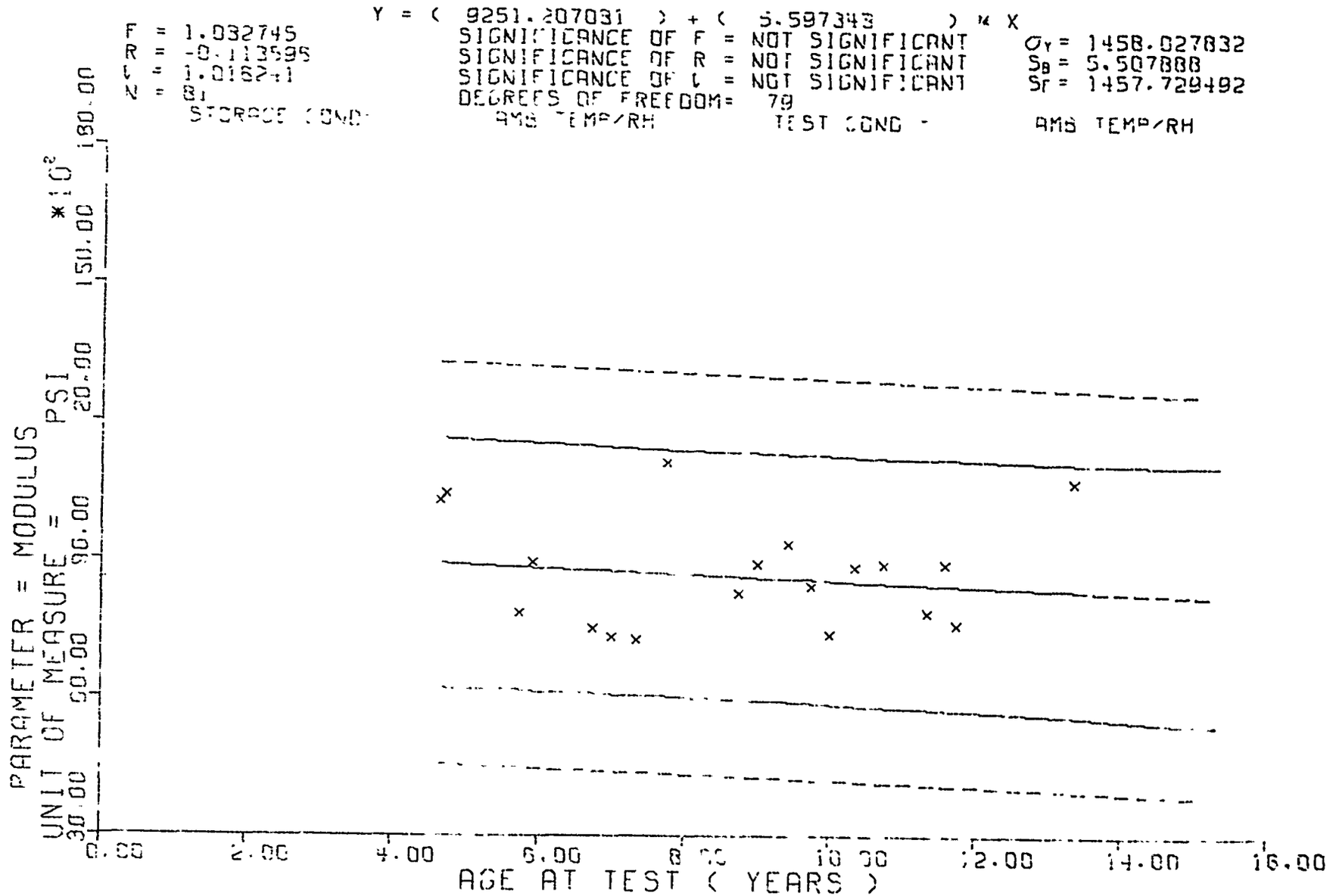
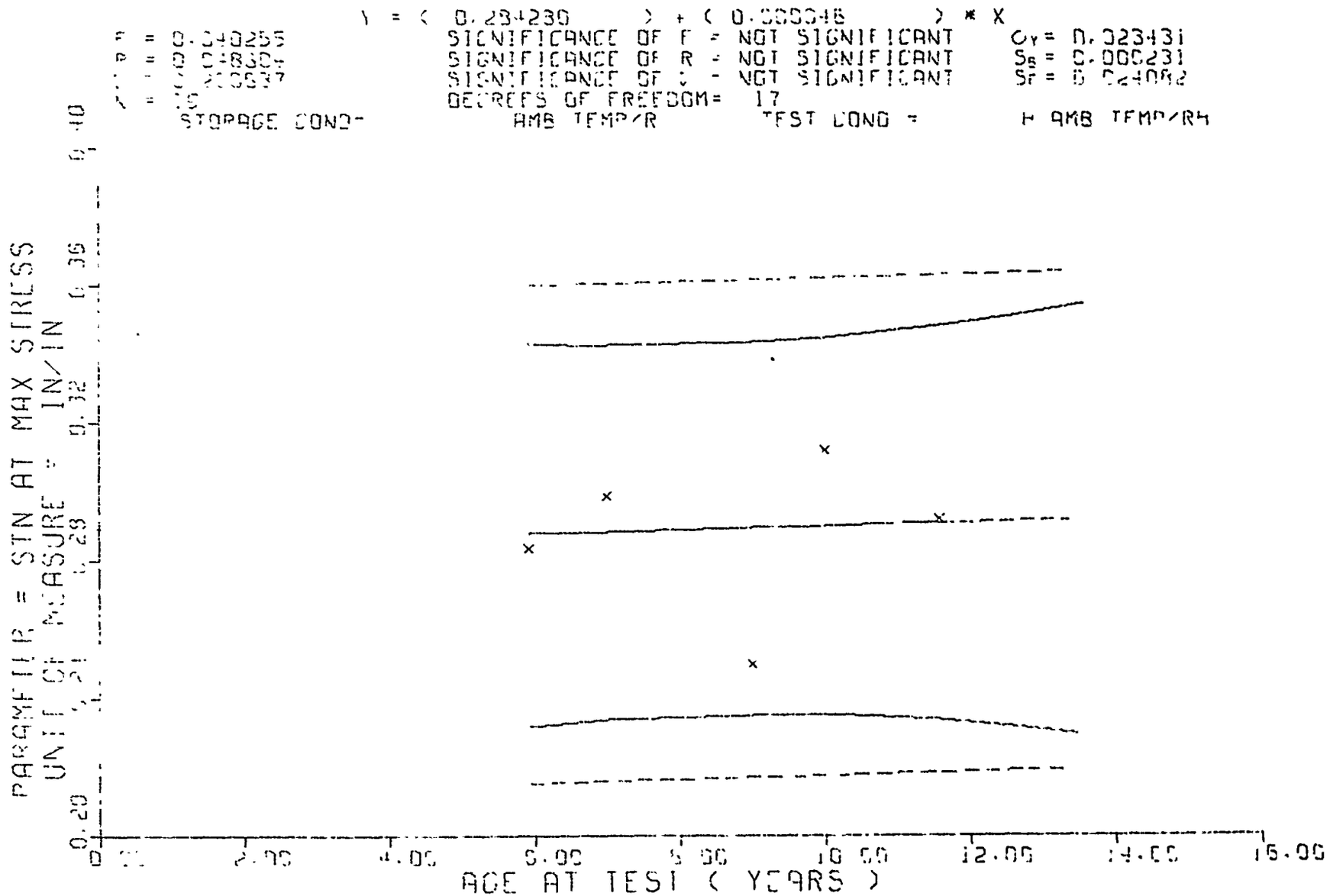

Y = (9251.207031) + (5.597343) * X
F = 1.032745
R = -0.113595
t = 1.016241
N = 81
SIGNIFICANCE OF F = NOT SIGNIFICANT
SIGNIFICANCE OF R = NOT SIGNIFICANT
SIGNIFICANCE OF t = NOT SIGNIFICANT
DEGREES OF FREEDOM= 79
σ_Y = 1458.027832
S_B = 5.507888
S_f = 1457.729492
STORAGE COND - AMB TEMP/RH
TEST COND - AMB TEMP/RH
PARAMETER = MODULUS
UNIT OF MEASURE = PSI *10²
30.00
60.00
90.00
120.00
150.00
180.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST (YEARS)
MODULUS, 1750 IN/MIN TRIAXIAL TENSILE @ 30% PSI, 5 MOTOR COMPOSITE

FIGURE 7-5

SAMPLE SIZE SUMMARY

AGE (MONTHS)	NR SAMPLES
71.0	4
84.0	6
108.0	3
120.0	3
139.0	3

HIGH RATE TRIAXIAL TENSILE STN AT MAX STRESS CHS 1750.0 300 PSI 0031064



HIGH RATE TRIAXIAL TENSILE STN AT MAX STRESS (HS 1730.0 300 PSI

FIGURE 7-6

Reproduced from best available copy.

SAMPLE SIZE SUMMARY

AGE (MONTHS)	NR SAMPLES
57.0	5
81.0	6
105.0	3
117.0	3
136.0	3

HIGH RATE TRIAXIAL TENSILE STN AT MAX STRESS CHS 1750.0 300 PSI 0031134

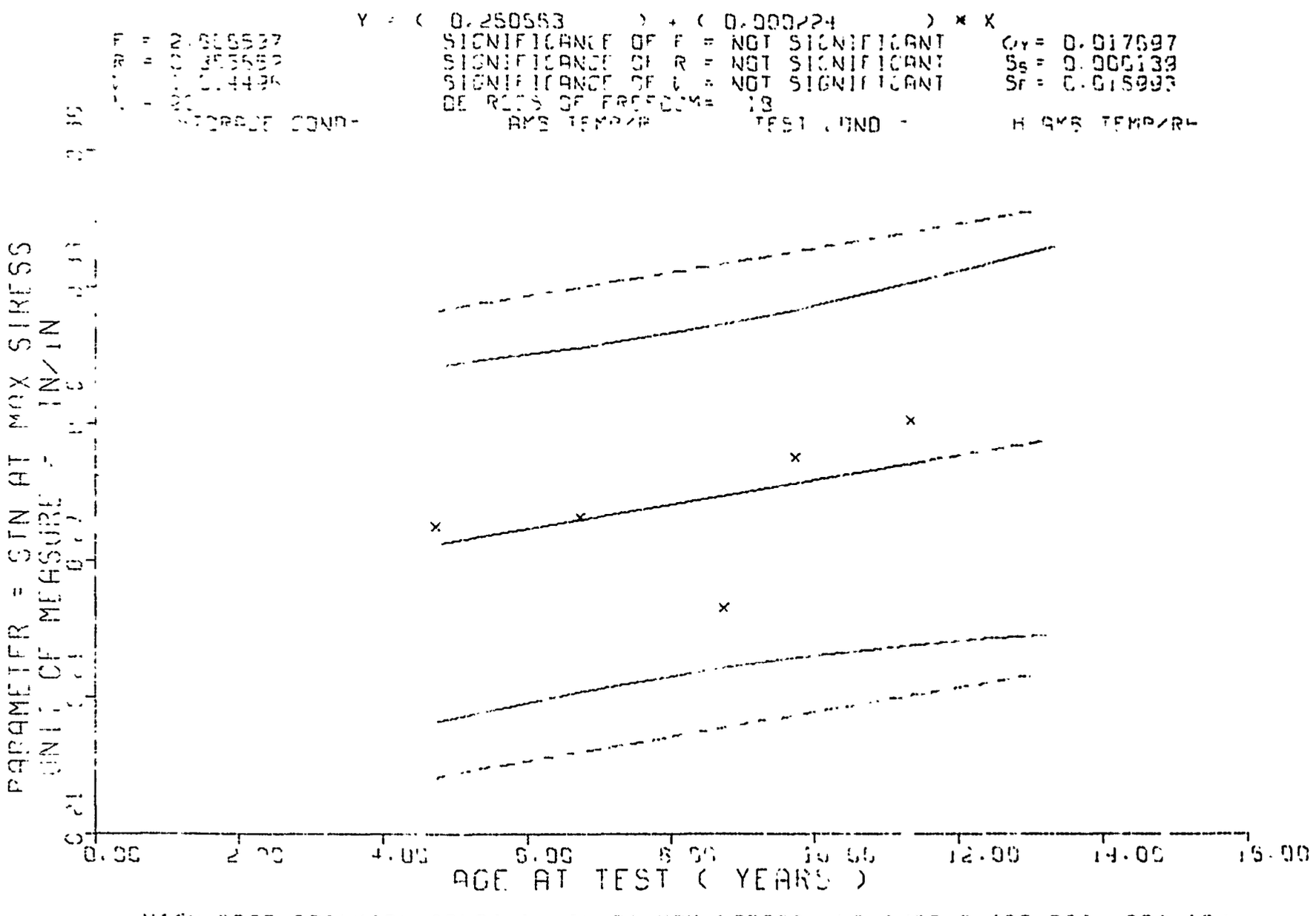

Y = (0.250553) + (0.000724) * X
SIGNIFICANCE OF F = NOT SIGNIFICANT
SIGNIFICANCE OF R = NOT SIGNIFICANT
SIGNIFICANCE OF L = NOT SIGNIFICANT
DEGREES OF FREEDOM= 18
Sy = 0.017697
Ss = 0.005139
Sf = 0.015993
PARAMETER = STN AT MAX STRESS
UNIT OF MEASURE = IN/IN
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST (YEARS)
HIGH RATE TRIAXIAL TENSILE STN AT MAX STRESS (MS 1750.0 300 PSI 003134

FIGURE 7-7

SAMPLE SIZE SUMMARY

AGE (MONTHS)	NR SAMPLES
56.0	5
69.0	5
93.0	3
105.0	3
136.0	3

HIGH RATE TRIAXIAL TENSILE STN AT MAX STRESS CHS 1750.0 300 PSI 0032434

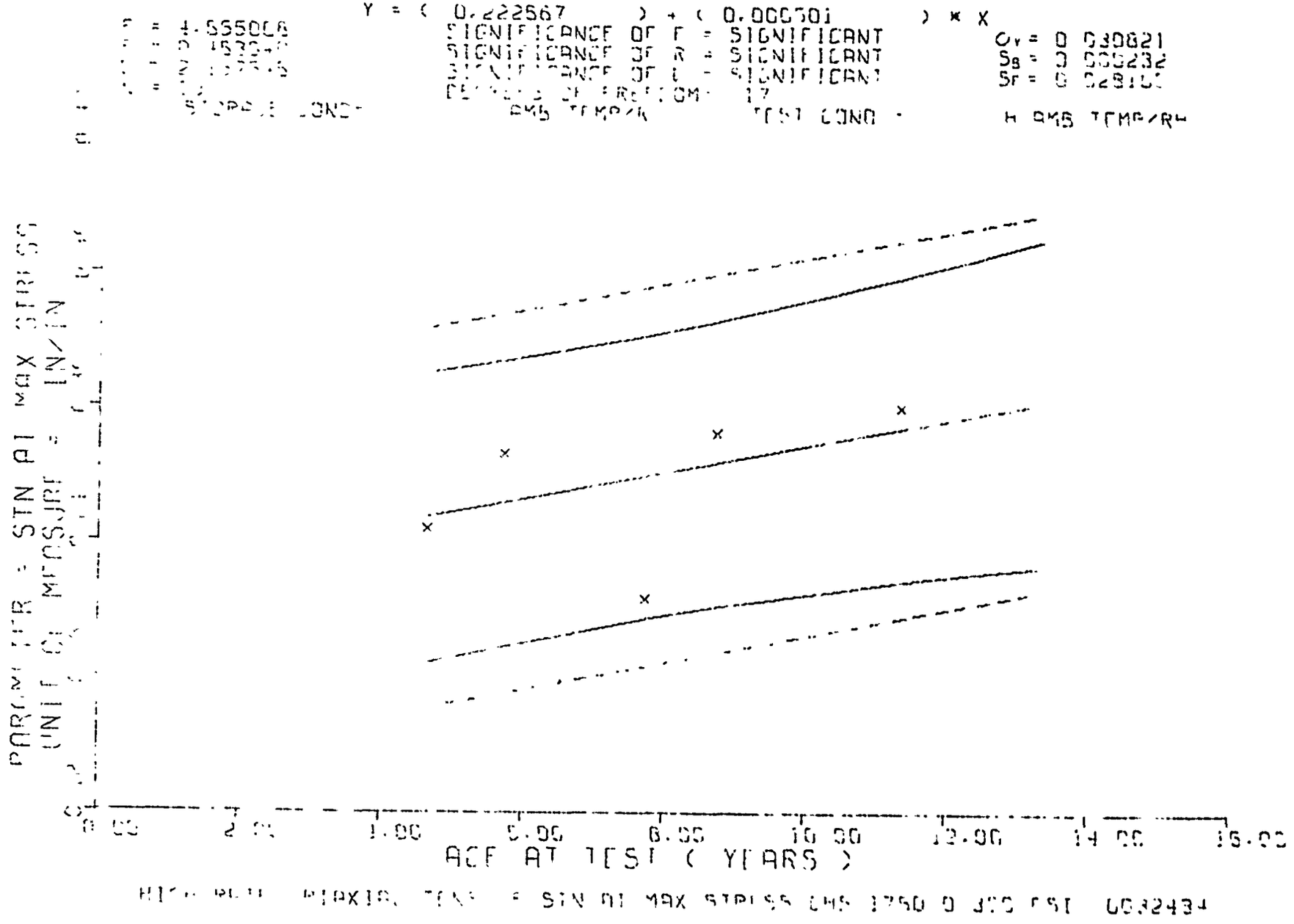

Y = (0.222567) + (0.000501) * X
SIGNIFICANCE OF F = SIGNIFICANT
SIGNIFICANCE OF R = SIGNIFICANT
SIGNIFICANCE OF L = SIGNIFICANT
DEGREES OF FREEDOM = 17
RMS TEMP/RH
TEST COND
H RMS TEMP/RH
PARAM ATR = STN DI MAX STRESS
UNIT OF MEASURE = IN/IN
1.00
5.00
6.00
10.00
12.00
14.00
16.00
ACF AT TEST (YEARS)

FIGURE 7-8

SAMPLE SIZE SUMMARY

AGE (MONTHS)	NR SAMPLES
57.0	3
69.0	3
88.0	3

HIGH RATE TRIAXIAL TENSILE STN AT MAX STRESS CHS 1750.0 300 PSI 0033174

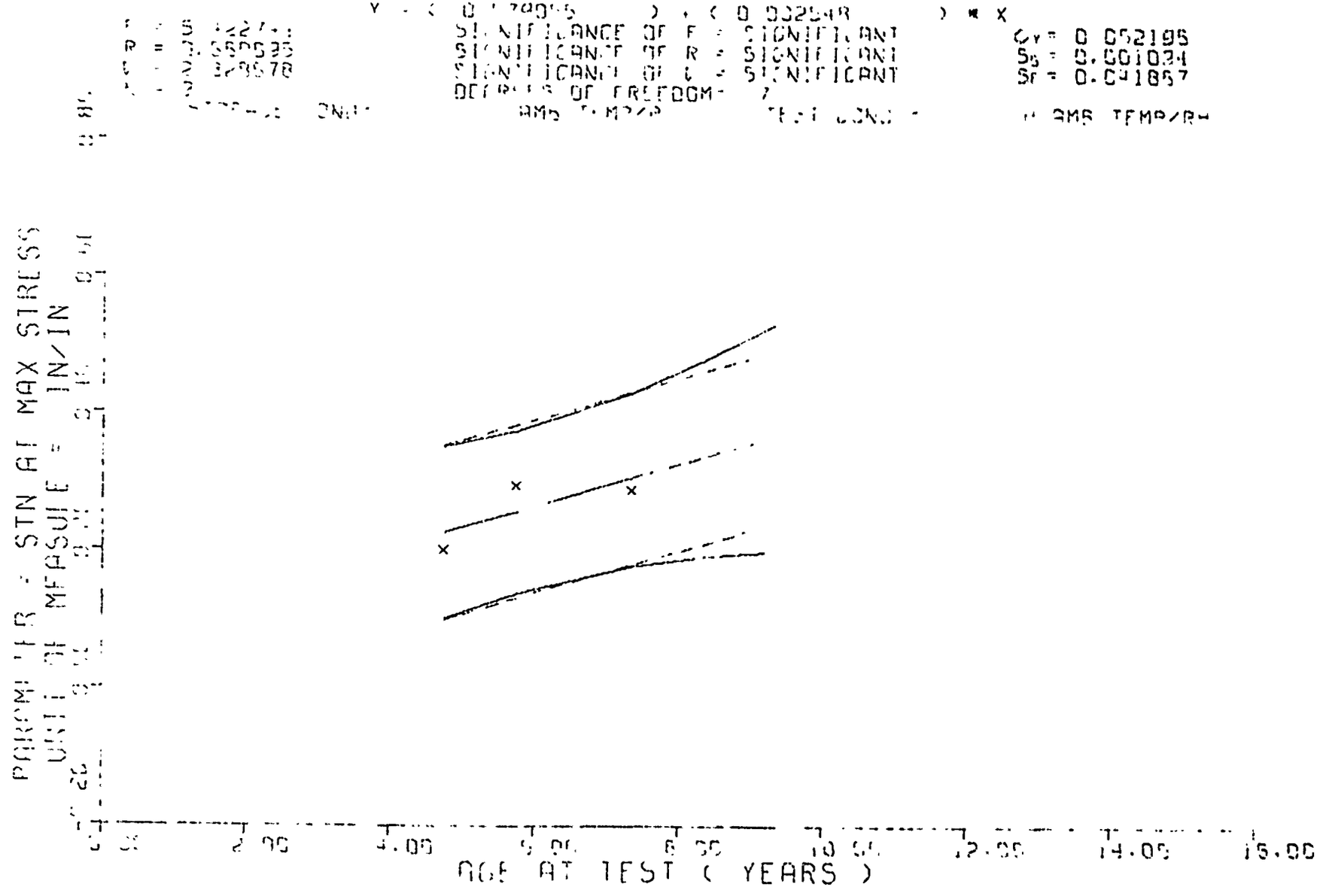

SIGNIFICANCE OF F = SIGNIFICANT
SIGNIFICANT OF R = SIGNIFICANT
SIGNIFICANT OF L = SIGNIFICANT
DEGREES OF FREEDOM= 7
Cv= 0.052195
Sb= 0.001034
Sr= 0.041857
PRINCIPAL STN AT MAX STRESS
UNIT OF MEASURE = IN/IN
AGE AT TEST (YEARS)
2.00
4.00
6.00
10.00
12.00
14.00
16.00

FIGURE 7-9

SAMPLE SIZE SUMMARY

AGE (MONTHS)	NR SAMPLES
105.0	3
113.0	2
129.0	3
141.0	3
160.0	3

HIGH RATE TRIAXIAL TENSILE STN AT MAX STRESS CHS 1750.0 300 PSI C 131

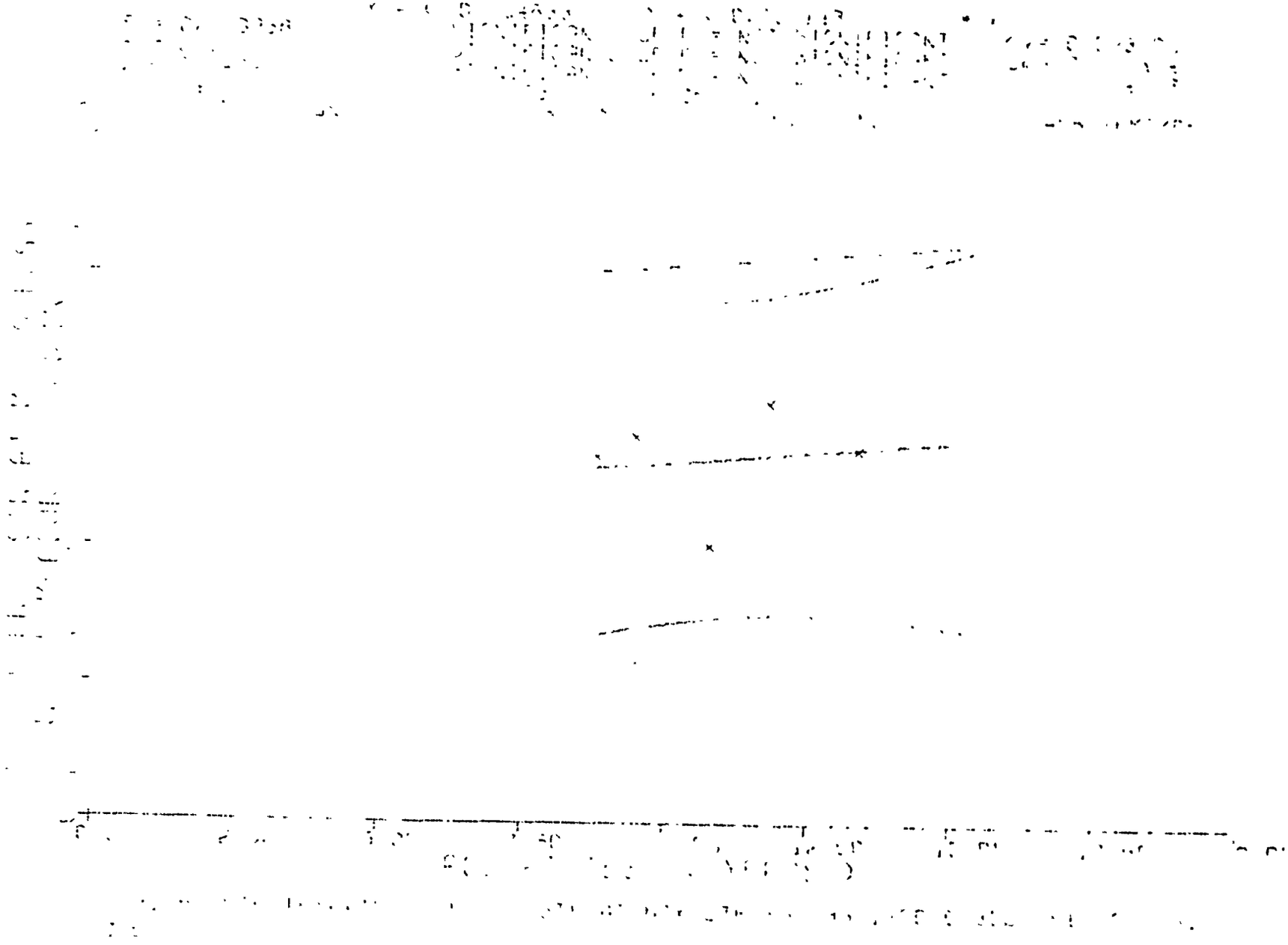


FIGURE 7-10

SECTION VIII

STRESS RELAXATION

End bonded 1/2" x 1/2" x 4" specimens are tested on the RCK Stress Relaxometer. Specimens are strained initially to 3% and then permitted to relax up to 1000 seconds. The strain rate is 0.5 in/in/min.

Stress relaxation modulus for the five motors composite shows a significant increase (Figure 8-1 thru 8-4).

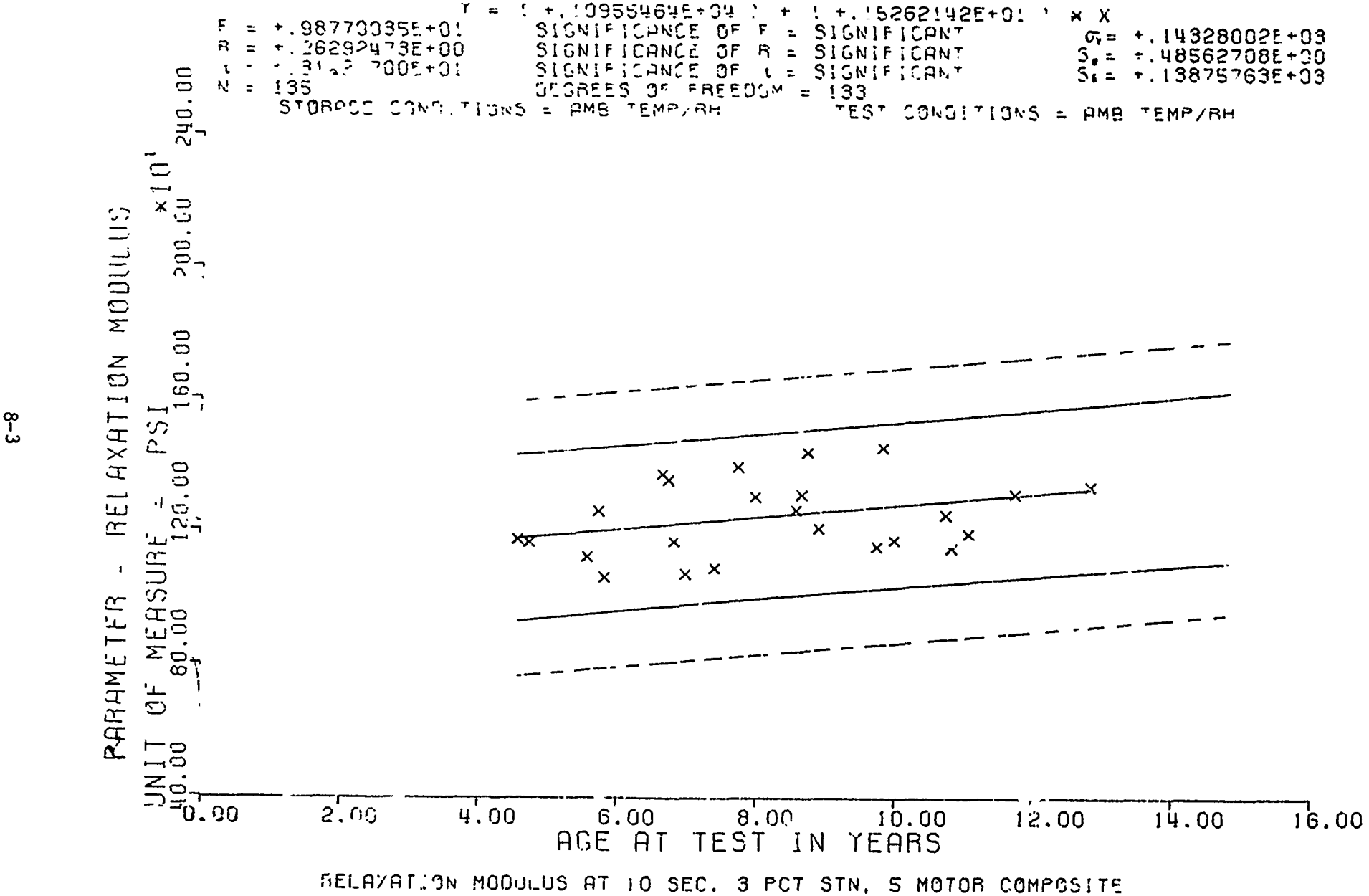
A comparison with 1968 data shows that Motor 0031064 has a slightly higher modulus now (1066 psi vs 1197), 0031134 remains the same (1123 psi vs 1153), and 0032434 is higher (1176 psi vs 1457).

When 10 sec and 1000 sec relaxation modulus is examined for individual motors the trend is significant for motors 0031064, 0031134 and 0032434. There is no trend for 0033174. The modulus at 1000 sec is less than 50% of the 10 sec value. Motor 0031064 shows approximately 50% reduction but motors 0032434 has a 1000 sec modulus which is more than 60% of the 10 sec value.

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
55.0	10
57.0	6
67.0	10
69.0	6
70.0	10
80.0	3
81.0	12
82.0	3
84.0	6
89.0	3
93.0	12
96.0	6
103.0	6
104.0	6
105.0	3
107.0	6
117.0	6
118.0	3
120.0	3
129.0	3
130.0	3
133.0	3
141.0	3
154.0	3

RELAXATION MODULUS AT 10 SEC, 3 PCT STN, 5 MOTOR COMPOSITE



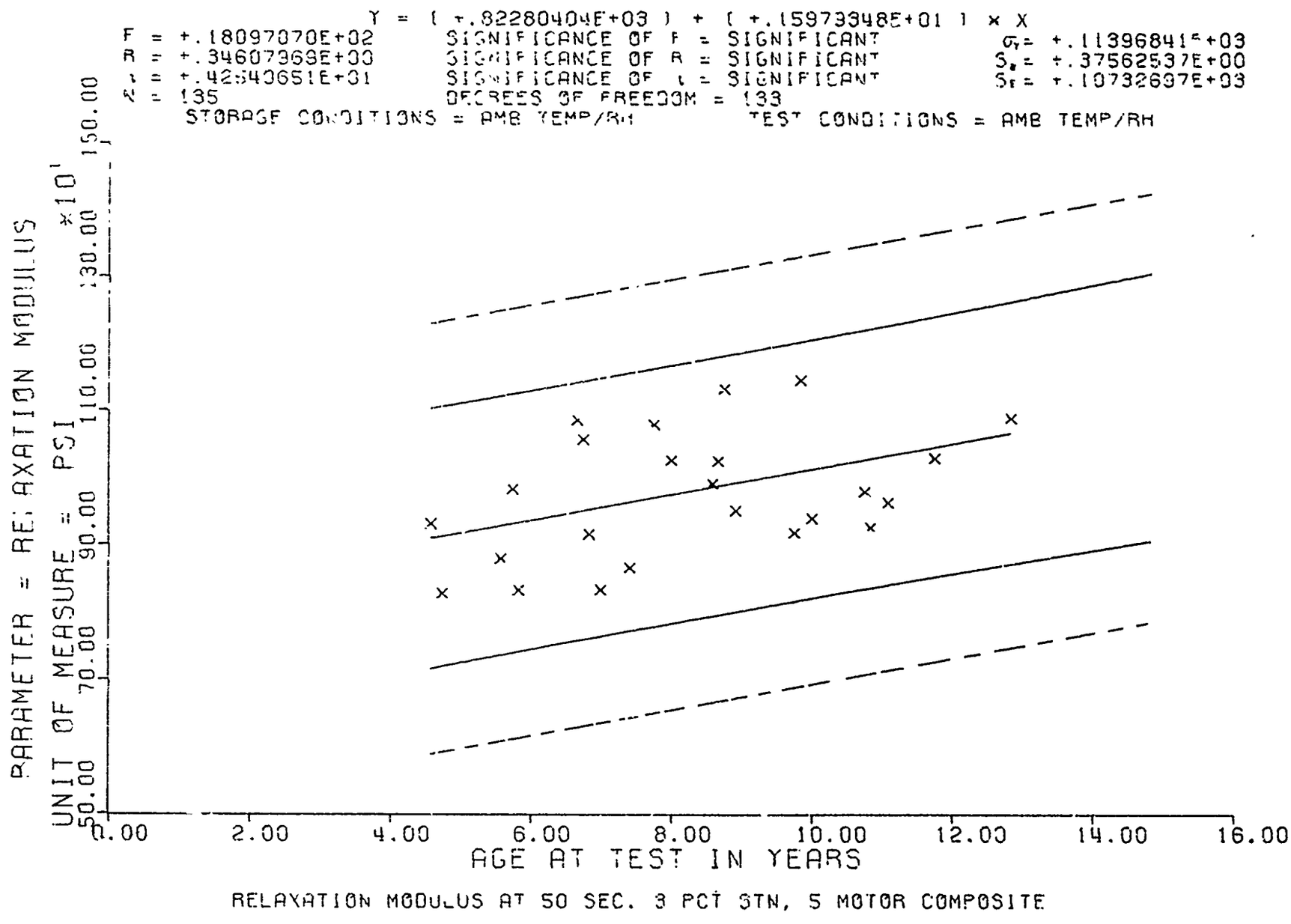
RELAXATION MODULUS AT 10 SEC. 3 PCT STN. 5 MOTOR COMPOSITE

Figure 8-1

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
55.0	105
57.0	6
67.0	10
69.0	6
70.0	10
80.0	3
81.0	12
82.0	3
84.0	6
89.0	3
93.0	12
96.0	6
103.0	6
104.0	6
105.0	3
107.0	6
117.0	6
118.0	3
120.0	3
129.0	3
130.0	3
133.0	3
141.0	3
154.0	3

RELAXATION MODULUS AT 50 SEC, 3 PCT STN, 5 MOTOR COMPOSITE



RELAXATION MODULUS AT 50 SEC. 3 PCT STN, 5 MOTOR COMPOSITE

Figure 8-2

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
(55.0S)	10S
57.0	6
67.0	10
69.0	6
70.0	10
80.0	3
81.0	12
82.0	3
84.0	6
89.0	3
93.0	12
96.0	6
103.0	6
104.0	6
105.0	3
107.0	6
117.0	6
118.0	3
123.0	3
129.0	3
130.0	3
133.0	3
141.0	3
154.0	3

RELAXATION MODULUS AT 100 SEC, 3 PCT STN, 5 MOTOR COMPOSITE

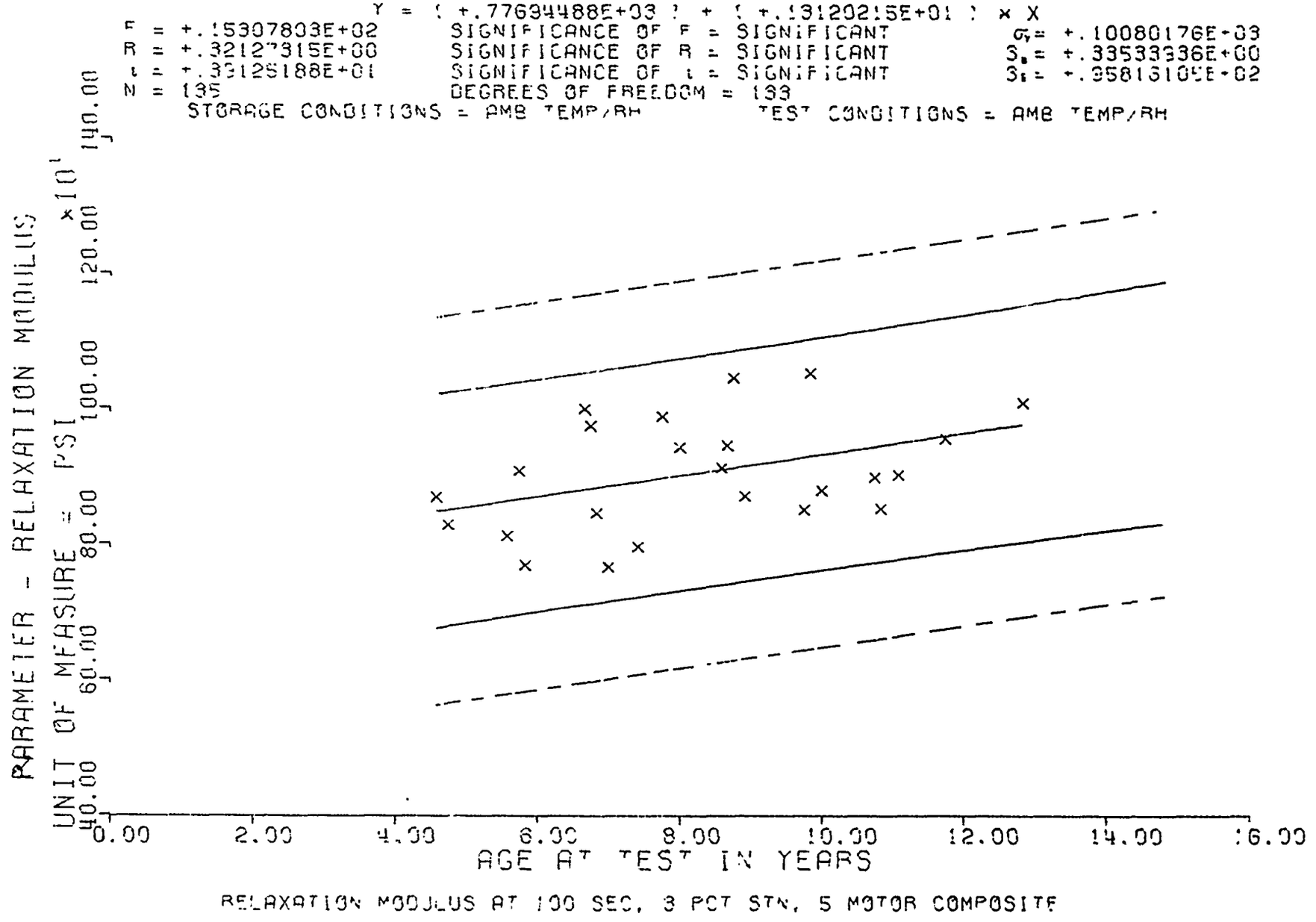

Y = (+.77634488E+03) + (+.13120215E+01) × X
F = +.15307803E+02 SIGNIFICANCE OF F = SIGNIFICANT
R = +.32127315E+00 SIGNIFICANCE OF R = SIGNIFICANT
t = +.39125188E+01 SIGNIFICANCE OF t = SIGNIFICANT
N = 135 DEGREES OF FREEDOM = 133
STORAGE CONDITIONS = AMB TEMP/RH
TEST CONDITIONS = AMB TEMP/RH
PARAMETER - RELAXATION MODULUS
UNIT OF MEASURE = PSI ×10¹
40.00
60.00
80.00
100.00
120.00
140.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST IN YEARS
RELAXATION MODULUS AT 100 SEC, 3 PCT STN, 5 MOTOR COMPOSITE

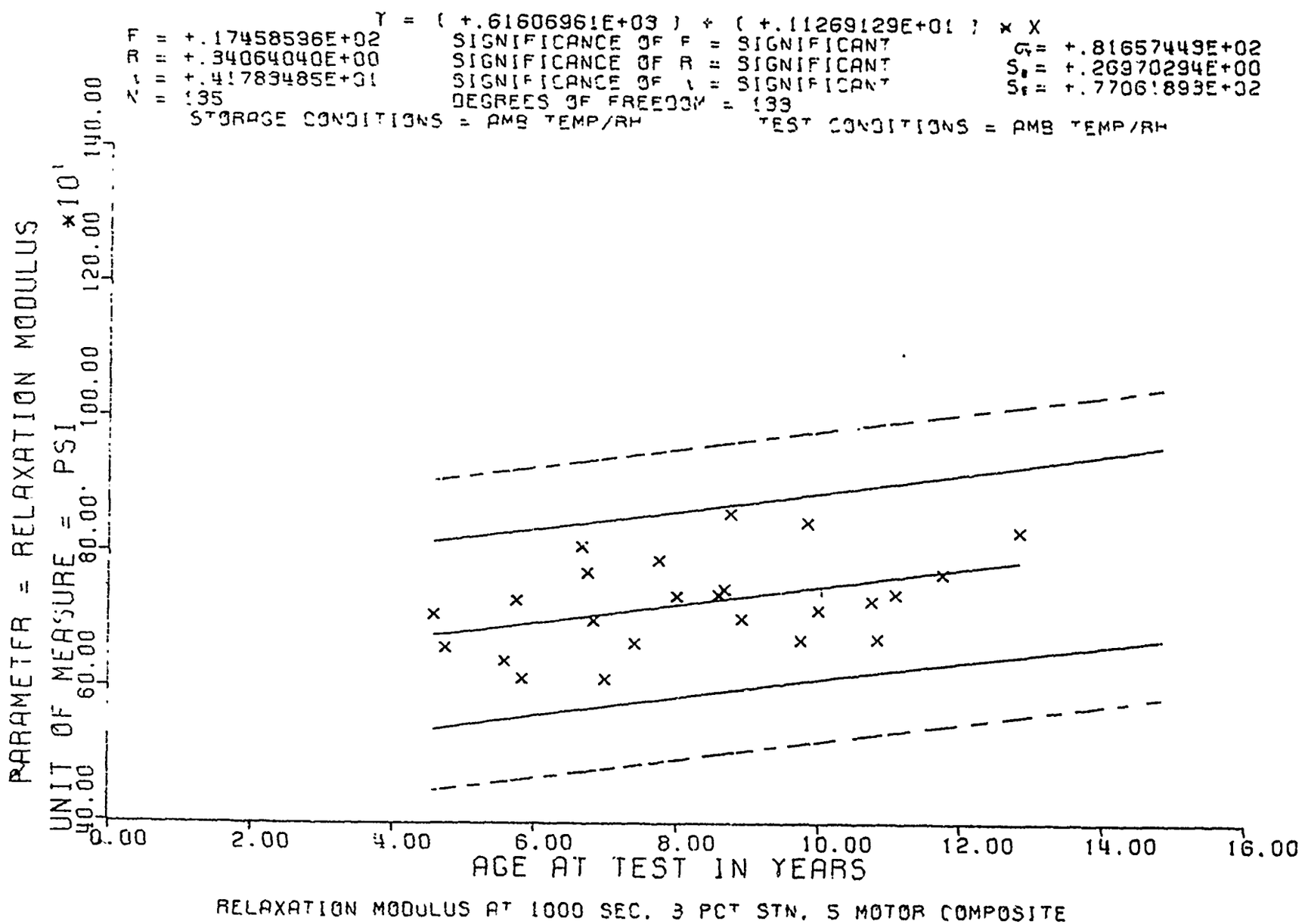
Figure 8-3

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
(55.95)	105
57.0	6
67.0	10
69.0	6
70.0	10
80.0	3
81.0	12
82.0	3
84.0	6
89.0	3
93.0	12
96.0	6
103.0	6
104.0	6
105.0	3
107.0	6
117.0	6
118.0	3
120.0	3
129.0	3
130.0	3
133.0	3
141.0	3
154.0	3

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RELAXATION MODULUS AT 1000 SEC. 3 PCT STN. 5 MOTOR COMPOSITE



RELAXATION MODULUS AT 1000 SEC. 3 PCT STN. 5 MOTOR COMPOSITE

Figure 8-4

SAMPLE SIZE SUMMARY

AGE (MONTHS)	NR SAMPLES
70.0	10
84.0	6
96.0	6
107.0	6
120.0	3
133.0	3

10 Sec Stress Relaxation Modulus E(T) at 3% Strain, Motor 0031064

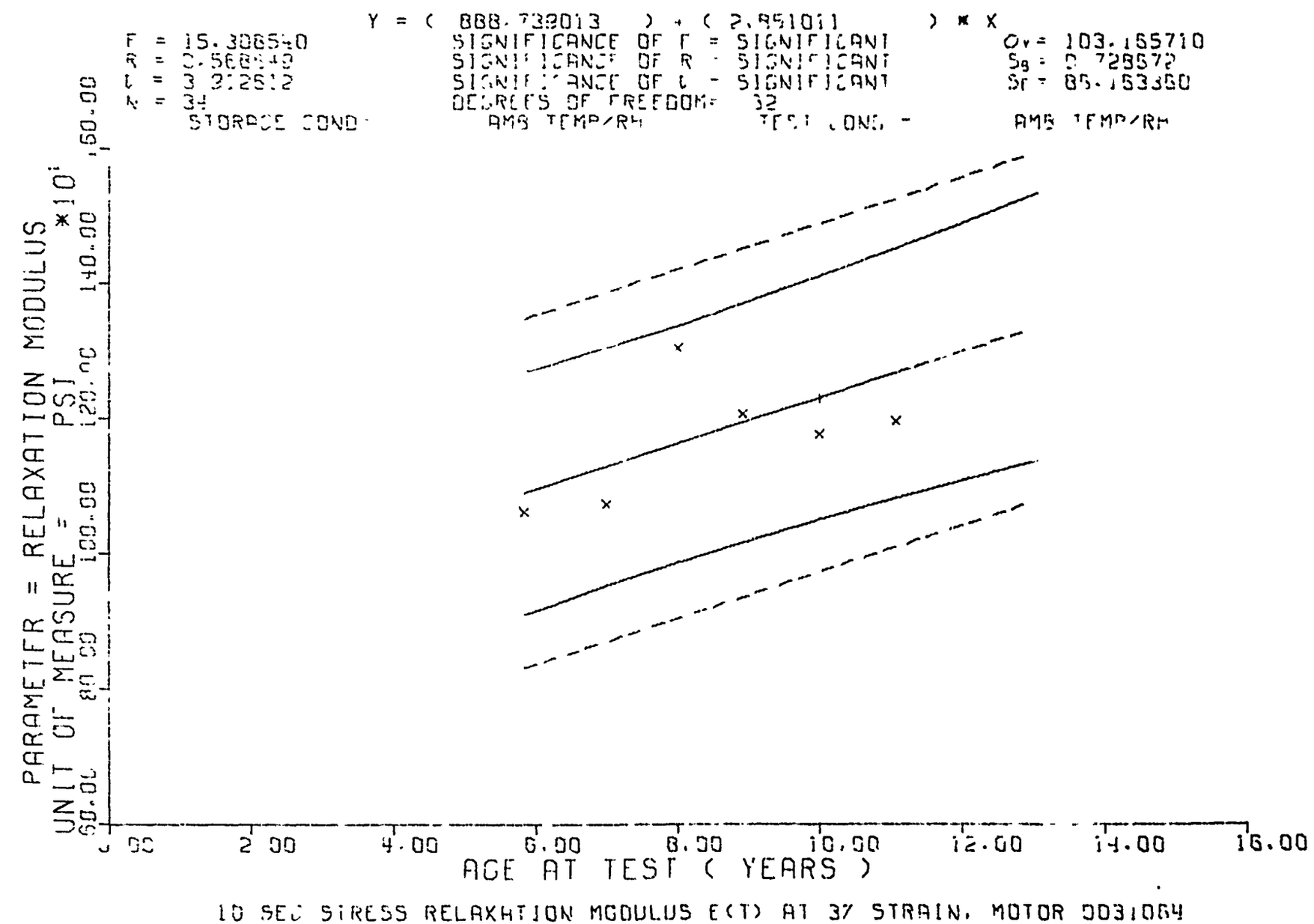

Y = (888.739013) + (2.951011) * X
F = 15.308540
R = 0.568949
t = 3.912512
N = 34
SIGNIFICANCE OF F = SIGNIFICANT
SIGNIFICANCE OF R = SIGNIFICANT
SIGNIFICANCE OF t = SIGNIFICANT
DEGREES OF FREEDOM= 32
Ov = 103.165710
Sg = 0.728572
Sr = 85.153350
STORAGE COND - AMB TEMP/RH
TEST COND. - AMB TEMP/RH
PARAMETER = RELAXATION MODULUS
UNIT OF MEASURE = PSI *10^5
60.00
80.00
100.00
120.00
140.00
160.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST (YEARS)
10 SEC STRESS RELAXATION MODULUS E(T) AT 3% STRAIN, MOTOR 0031064

Figure 8-5

SAMPLE SIZE SUMMARY

AGE (MONTHS)	NR SAMPLES
70.0	10
84.0	6
96.0	6
107.0	6
120.0	3
133.0	3

1000 SEC STRESS RELAXATION MODULUS E(T) AT 3% STRAIN, MOTOR 0031064

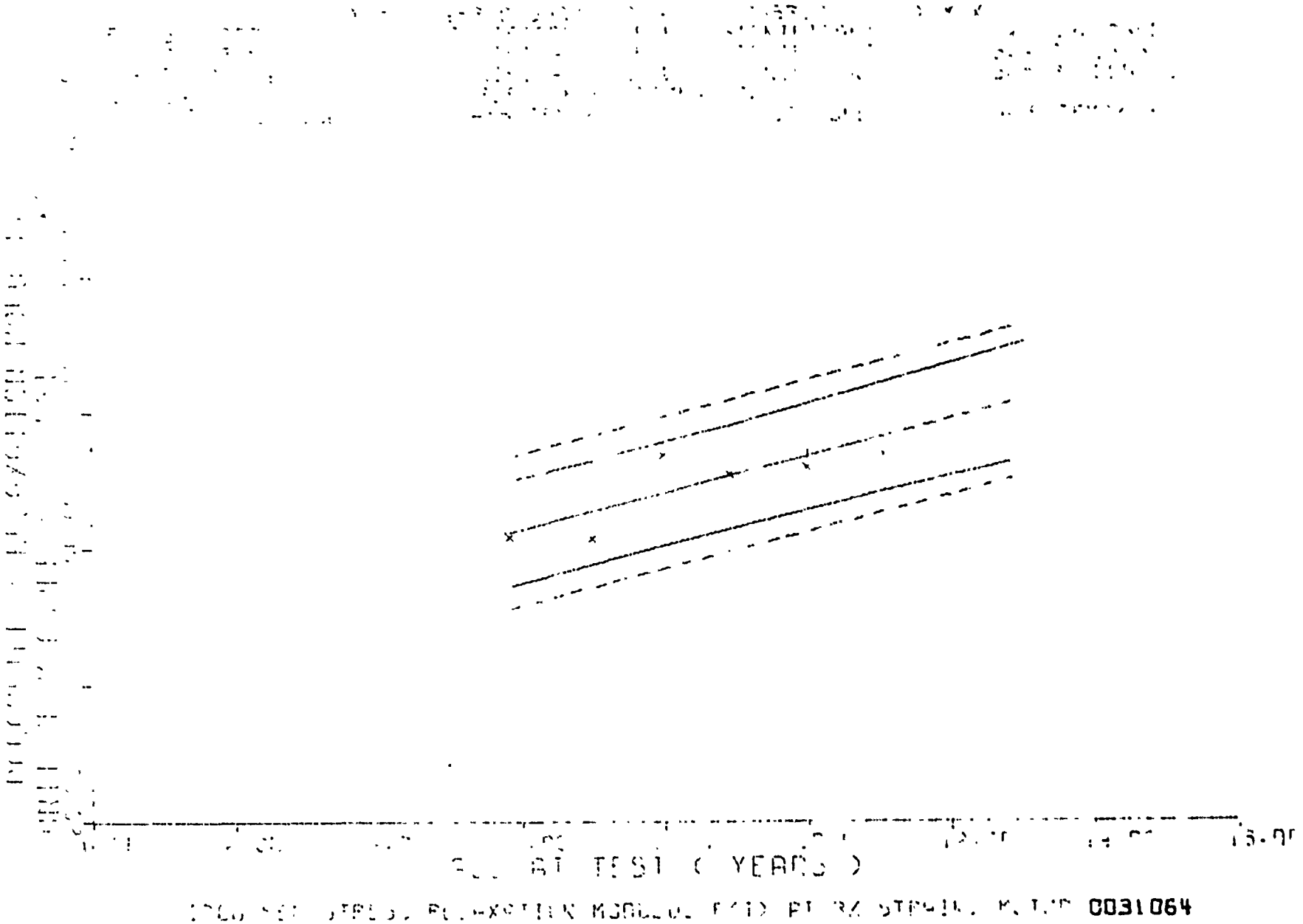


Figure 8-6

SAMPLE SIZE SUMMARY

AGE (MONTHS)	NR SAMPLES
67.0	10
81.0	6
93.0	6
104.0	6
117.0	3
130.0	3

10 Sec Stress Relaxation Modulus E(T) at 3% Strain, Motor 0031134

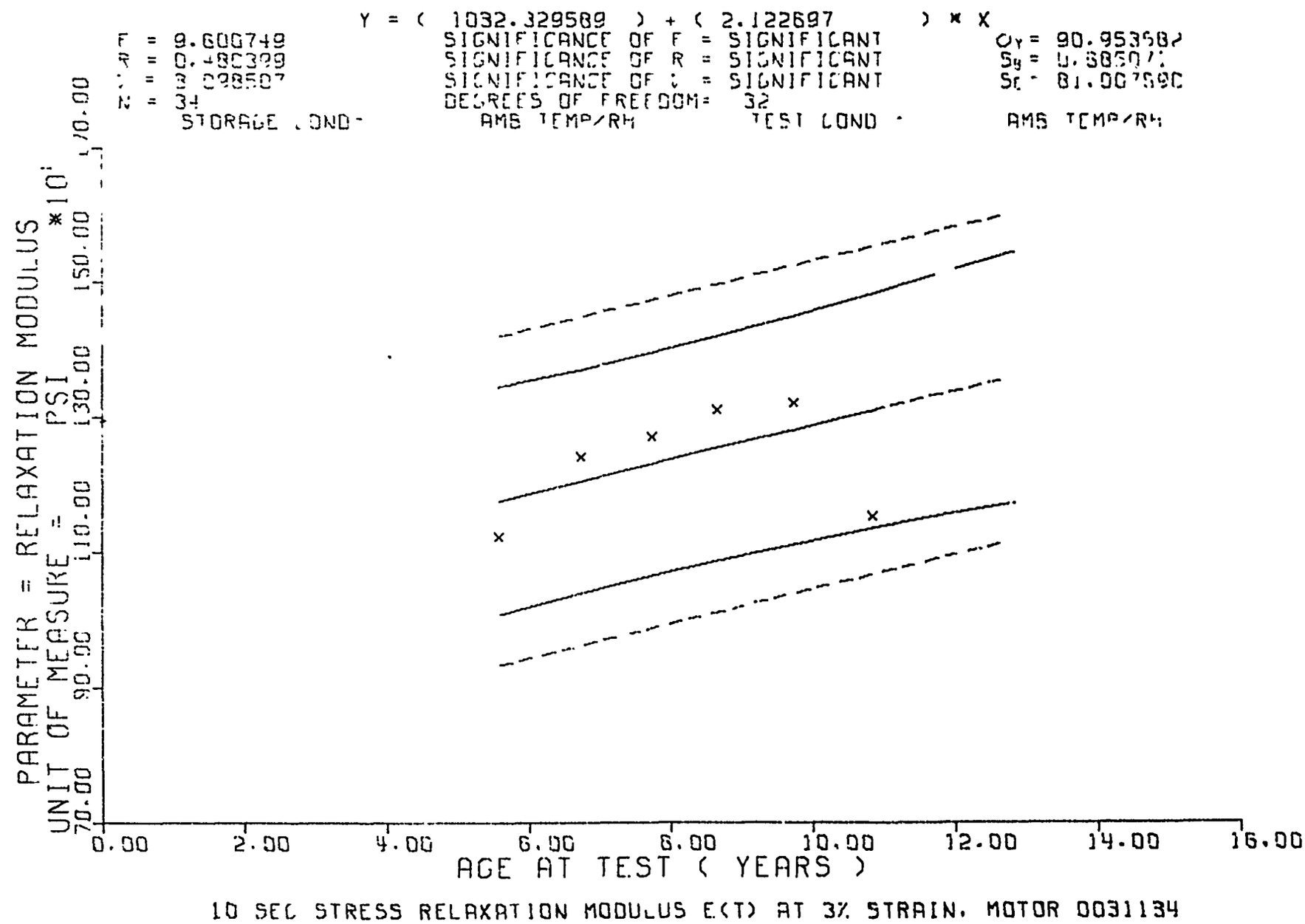

Y = (1032.329589) + (2.122697) * X
F = 9.600749
R = 0.480399
N = 34
SIGNIFICANCE OF F = SIGNIFICANT
SIGNIFICANCE OF R = SIGNIFICANT
DEGREES OF FREEDOM= 32
STORAGE COND
AMB TEMP/RH
TEST COND
AMB TEMP/RH
PARAMETER = RELAXATION MODULUS
UNIT OF MEASURE = PSI *10^3
70.00
90.00
110.00
130.00
150.00
170.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST (YEARS)
10 SEC STRESS RELAXATION MODULUS E(T) AT 3% STRAIN, MOTOR 0031134

Figure 8-7

SAMPLE SIZE SUMMARY

AGE (MONTHS)	NR SAMPLES
67.0	10
81.0	6
93.0	6
104.0	6
117.0	3
130.0	3

1000 SEC STRESS RELAXATION MODULUS E(T) AT 3% STRAIN, MOTOR 0031134

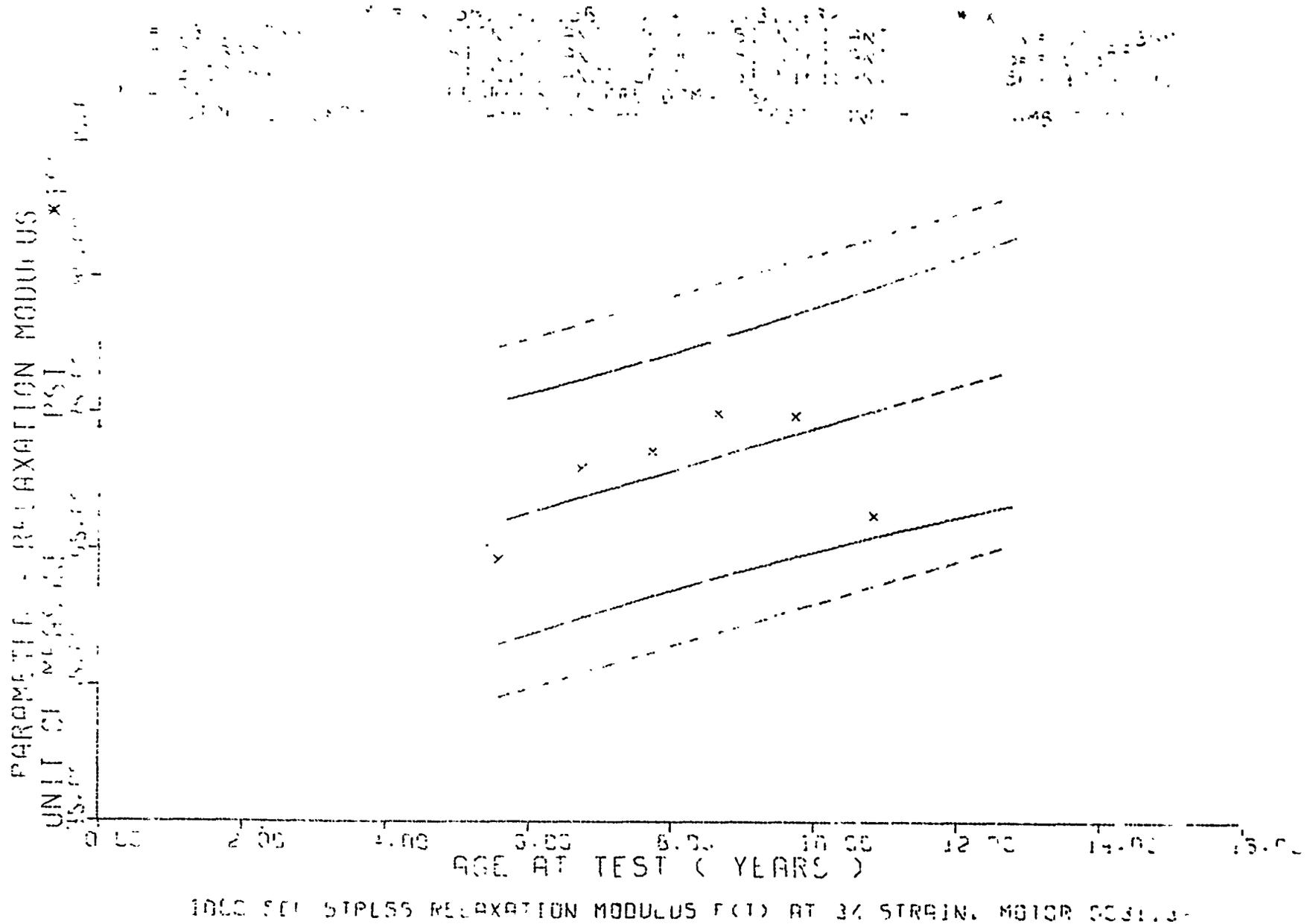


Figure 8-8

SAMPLE SIZE SUMMARY

AGE (MONTHS)	NR SAMPLES
55.0	10
69.0	6
81.0	6
93.0	6
105.0	3
118.0	3

10 Sec Stress Relaxation Modulus E(T) at 3% Strain, Motor 0032434

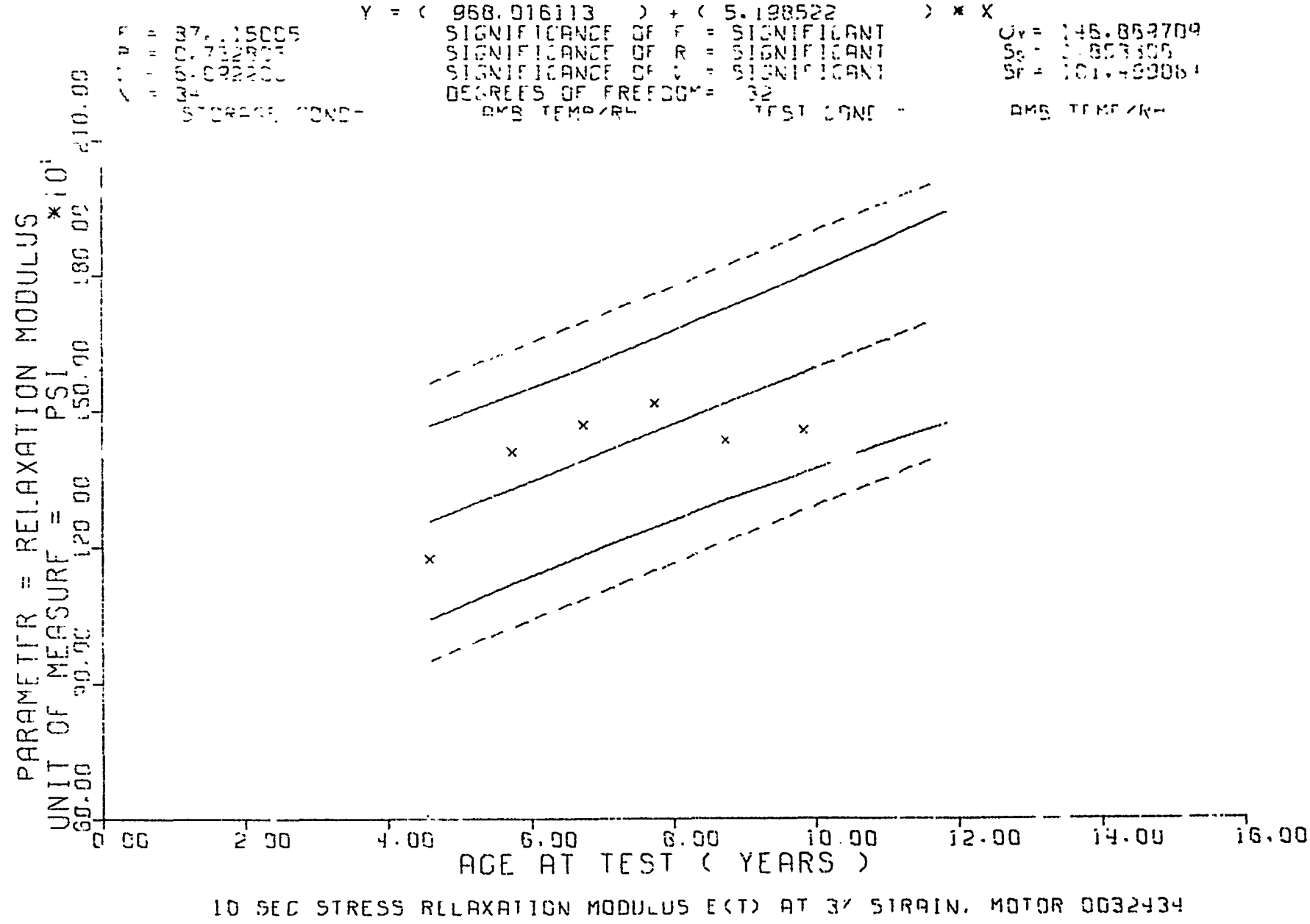

Y = (968.016113) + (5.198522) * X
SIGNIFICANCE OF F = SIGNIFICANT
SIGNIFICANCE OF R = SIGNIFICANT
SIGNIFICANCE OF [illegible] = SIGNIFICANT
DEGREES OF FREEDOM = 32
PARAMETER = RELAXATION MODULUS
UNIT OF MEASURE = PSI
*10^3
210.00
180.00
150.00
120.00
90.00
60.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST (YEARS)
10 SEC STRESS RELAXATION MODULUS E(T) AT 3% STRAIN, MOTOR 0032434

Figure 8-9

SAMPLE SIZE SUMMARY

AGE (MONTHS)	NR SAMPLES
55.0	10
69.0	6
81.0	6
93.0	6
105.0	3
118.0	3

1000 SEC STRESS RELAXATION MODULUS E(T) AT 3% STRAIN, MOTOR 0032434

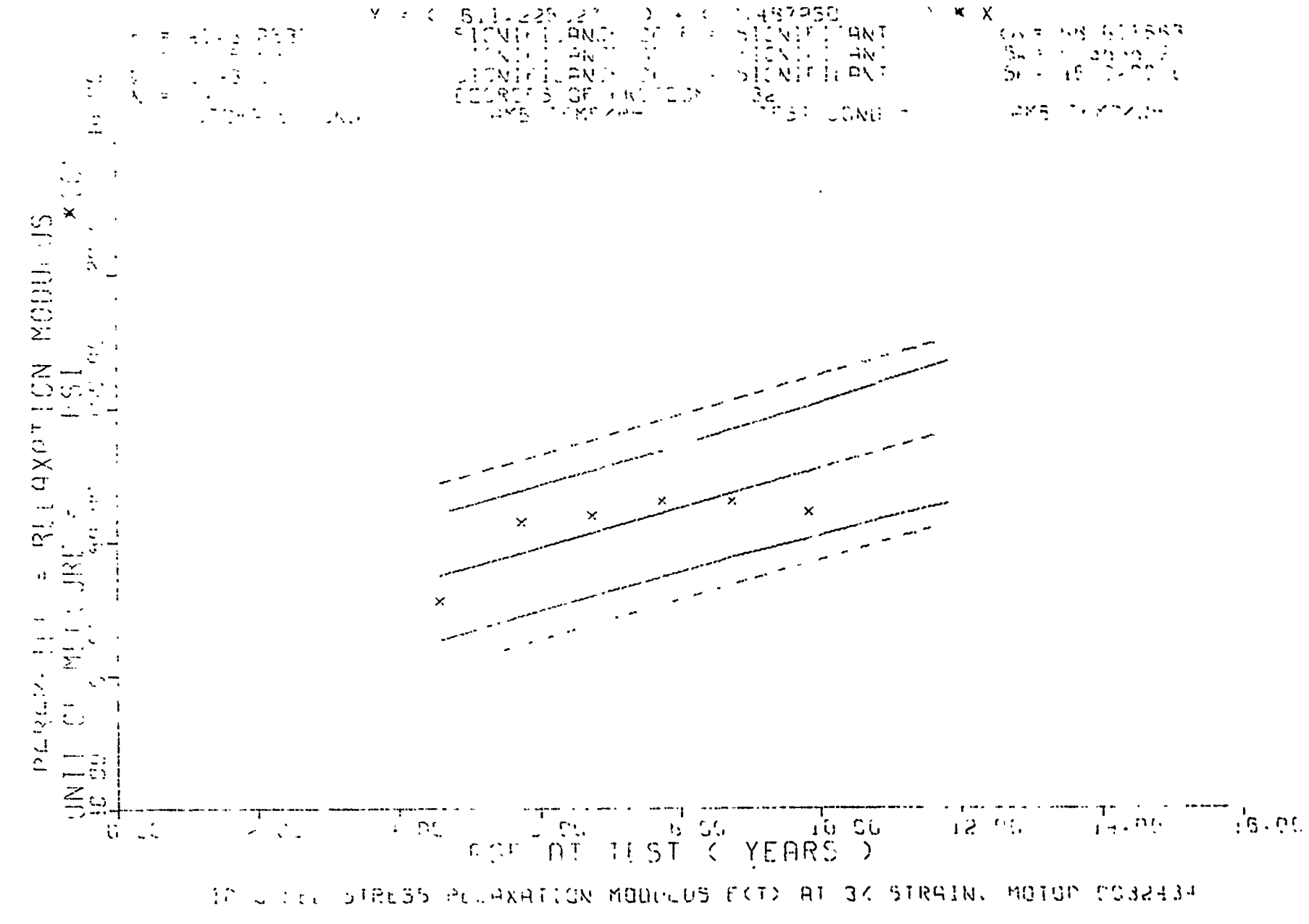


Figure 8-10

SAMPLE SIZE SUMMARY

AGE (MONTHS)	NR SAMPLES
57.0	6
69.0	3
82.0	3

10 Sec Stress Relaxation Modulus E(T) at 3% Strain, Motor 0033174

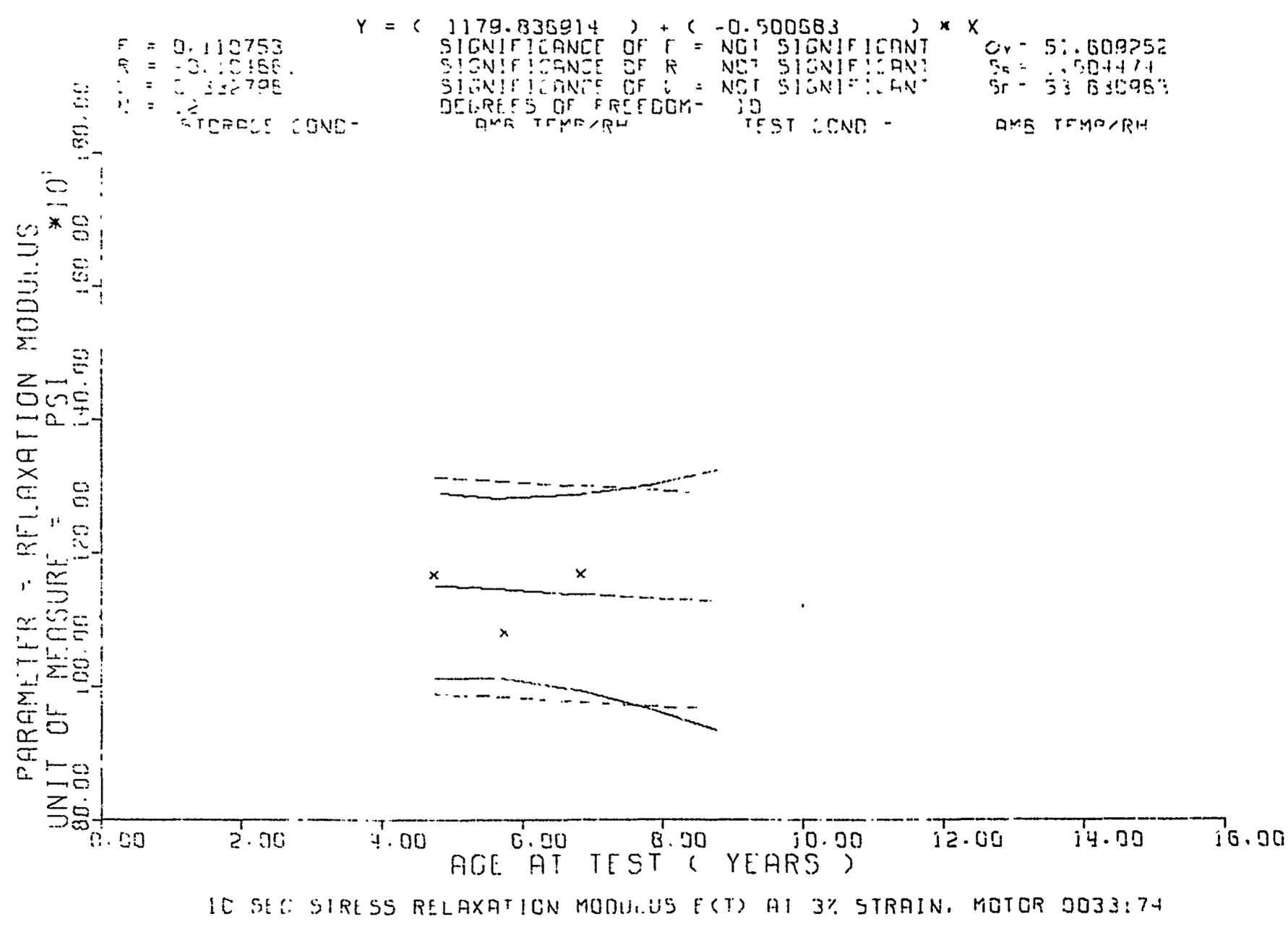
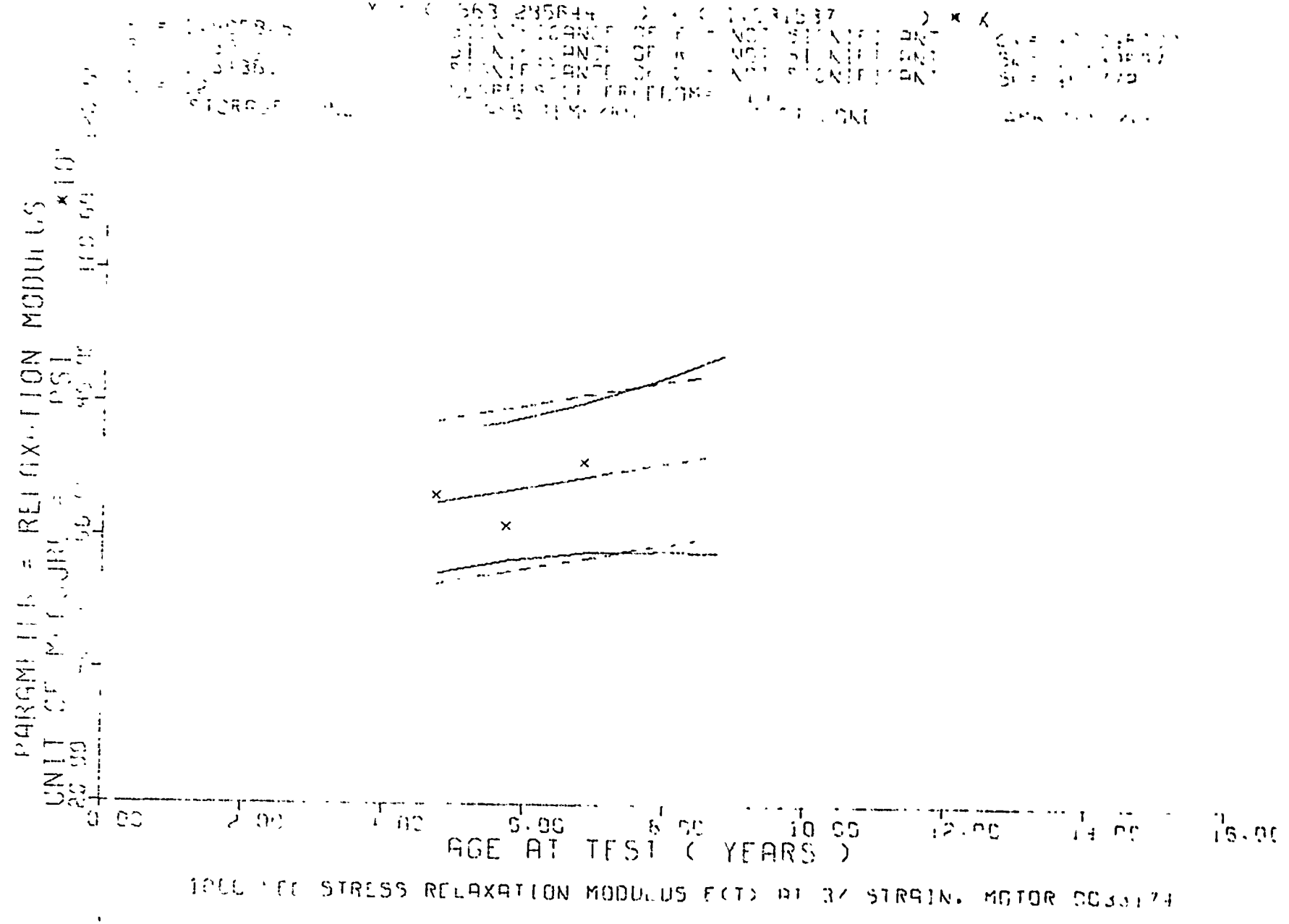

Y = (1179.836914) + (-0.500683) * X
SIGNIFICANCE OF F = NOT SIGNIFICANT
SIGNIFICANCE OF R NOT SIGNIFICANT
SIGNIFICANCE OF t = NOT SIGNIFICANT
DEGREES OF FREEDOM- 10
STORAGE COND- AMB TEMP/RH
TEST COND - AMB TEMP/RH
PARAMETER - RELAXATION MODULUS *10³
UNIT OF MEASURE = PSI
80.00
100.00
120.00
140.00
160.00
180.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST (YEARS)
10 SEC STRESS RELAXATION MODULUS E(T) AT 3% STRAIN, MOTOR 0033:74

Figure 8-11

SAMPLE SIZE SUMMARY

AGE (MONTHS)	NR SAMPLES
57.0	6
69.0	3
82.0	3

1000 SEC STRESS RELAXATION MODULUS E(T) AT 3% STRAIN, MOTOR 0033174



100 SEC STRESS RELAXATION MODULUS E(T) AT 3% STRAIN, MOTOR SC3[illegible]4

Figure 8-12

SECTION IX

HIGH RATE TENSILE

In an effort to bring the MANCP program closer to the proposed LRSLA program, limited dogbones were tested under high rate conditions. Data with and without pressure are given in the table below.

High Rate Dogbones - EGL 1.75 CSA 0.1875

Motor	Test Date	em	Sm	er	Sr	E
		Without Pressure				
31134	74028	.329	1552	.334	1546	7547
		.339	1543	.348	1532	7289
32434		.361	1351	.364	1345	5028
		.312	1461	.323	1456	6870
		.304	1486	.311	1477	6645
33174		.297	1465	.304	1455	7032
		.294	1459	.299	1454	7717
		.310	1487	.321	1476	6902
		300 psi				
31134	74165	.324	1343	.335	1334	5483
		.301	1379	.308	1369	6058
		.301	1290	.305	1286	5550
32434		.329	1261	.347	1247	5684
		.343	1277	.347	1270	5409
		.306	1474	.309	1464	8375
33174		.290	1281	.300	1270	6155
		.311	1334	.320	1325	6020
		.324	1413	.329	1408	6494

From this data, there does not seem to be an appreciable difference between specimens tested with and without pressure. The expected increase in strain capability is absent. This may be a result of the longer storage after specimen preparation.

SECTION X

HARDNESS

Shore A and Shore C durometer readings are taken on JANNAF dogbone ends prior to tensile testing.

There is a significant decrease in Shore A 10 second readings (Figure 10-1). This trend is undoubtedly the result of the lower values for 1973 testing.

There is a significant increase in Shore C 10 second readings (Figure 10-2). There is no consistency of readings between Shore A and Shore C, that is, the lows and highs do not show up in both sets of data at the same test period.

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
(-55.05)	15
58.0	10
67.0	1
68.0	1
69.0	5
70.0	1
80.0	1
82.0	5
83.0	1
84.0	5
93.0	5
95.0	5
97.0	5
98.0	5
103.0	4
105.0	20
108.0	10
113.0	5
115.0	5
118.0	5
120.0	5
130.0	10
133.0	5
138.0	5
154.0	5

SHORE A 10 SECOND HARDNESS, 5 MOTOR COMPOSITE

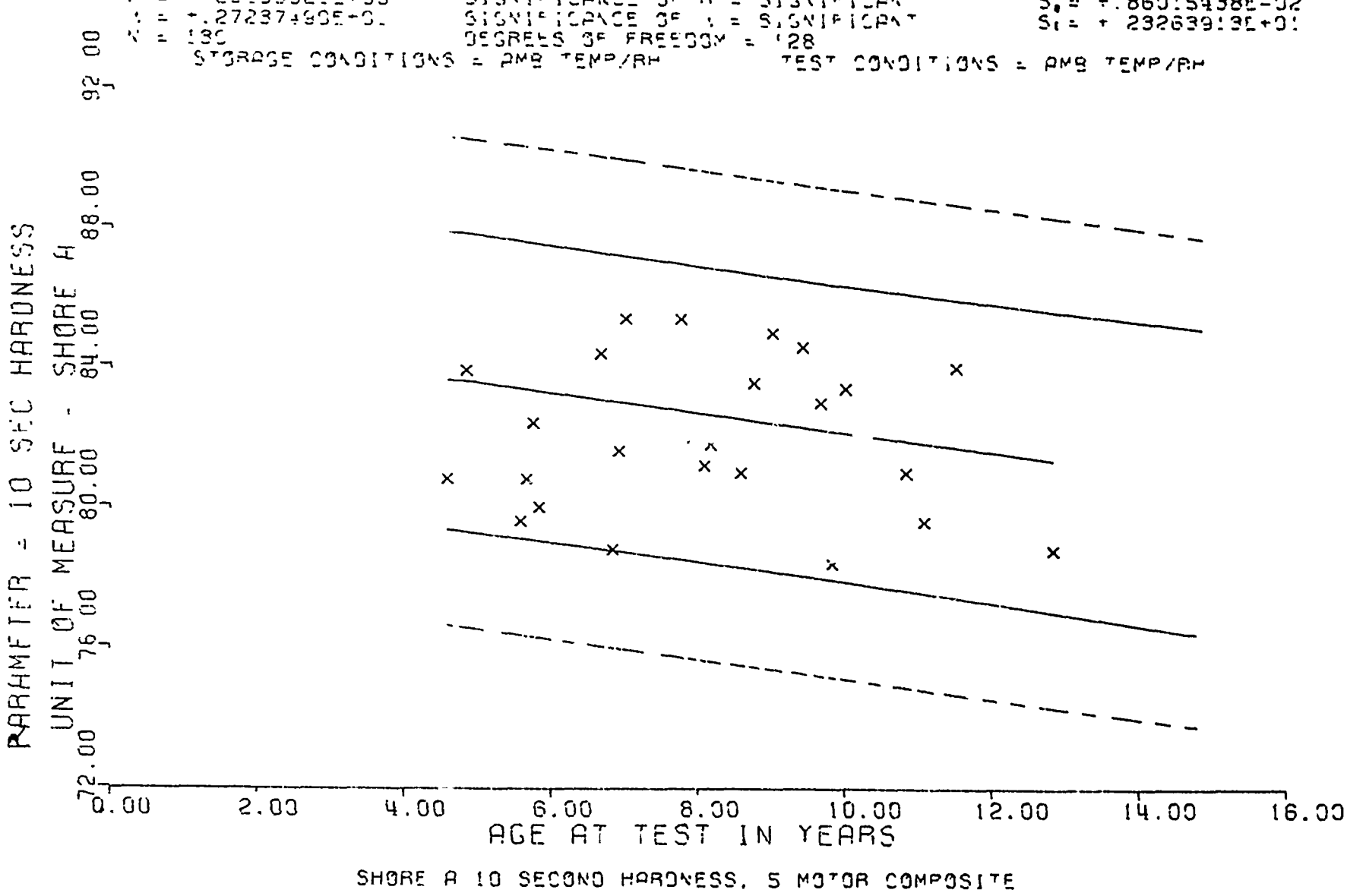

Y = (+.84924580E+02) + (-.23428447E-01) * X
F = +.74188091E+01
SIGNIFICANCE OF F = SIGNIFICANT
σ = +.23835672E+01
R = -.23406021E+00
SIGNIFICANCE OF R = SIGNIFICANT
S0 = +.86015438E-02
N = 130
DEGREES OF FREEDOM = 128
STORAGE CONDITIONS = AMB TEMP/RH
TEST CONDITIONS = AMB TEMP/RH
PARAMETER = 10 SEC HARDNESS
UNIT OF MEASURE - SHORE A
92.00
88.00
84.00
80.00
76.00
72.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST IN YEARS
SHORE A 10 SECOND HARDNESS, 5 MOTOR COMPOSITE

Figure 10-1

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NK SAMPLES
(55.05)	15
58.0	10
67.0	1
68.0	1
69.0	5
70.0	1
80.0	1
82.0	5
83.0	1
84.0	5
93.0	5
95.0	5
98.0	5
103.0	4
105.0	25
108.0	10
113.0	5
116.0	5
118.0	5
120.0	5
130.0	10
133.0	5
138.0	5
154.0	5

SHORE C 10 SECOND HARDNESS, 5 MOTOR COMPOSITE

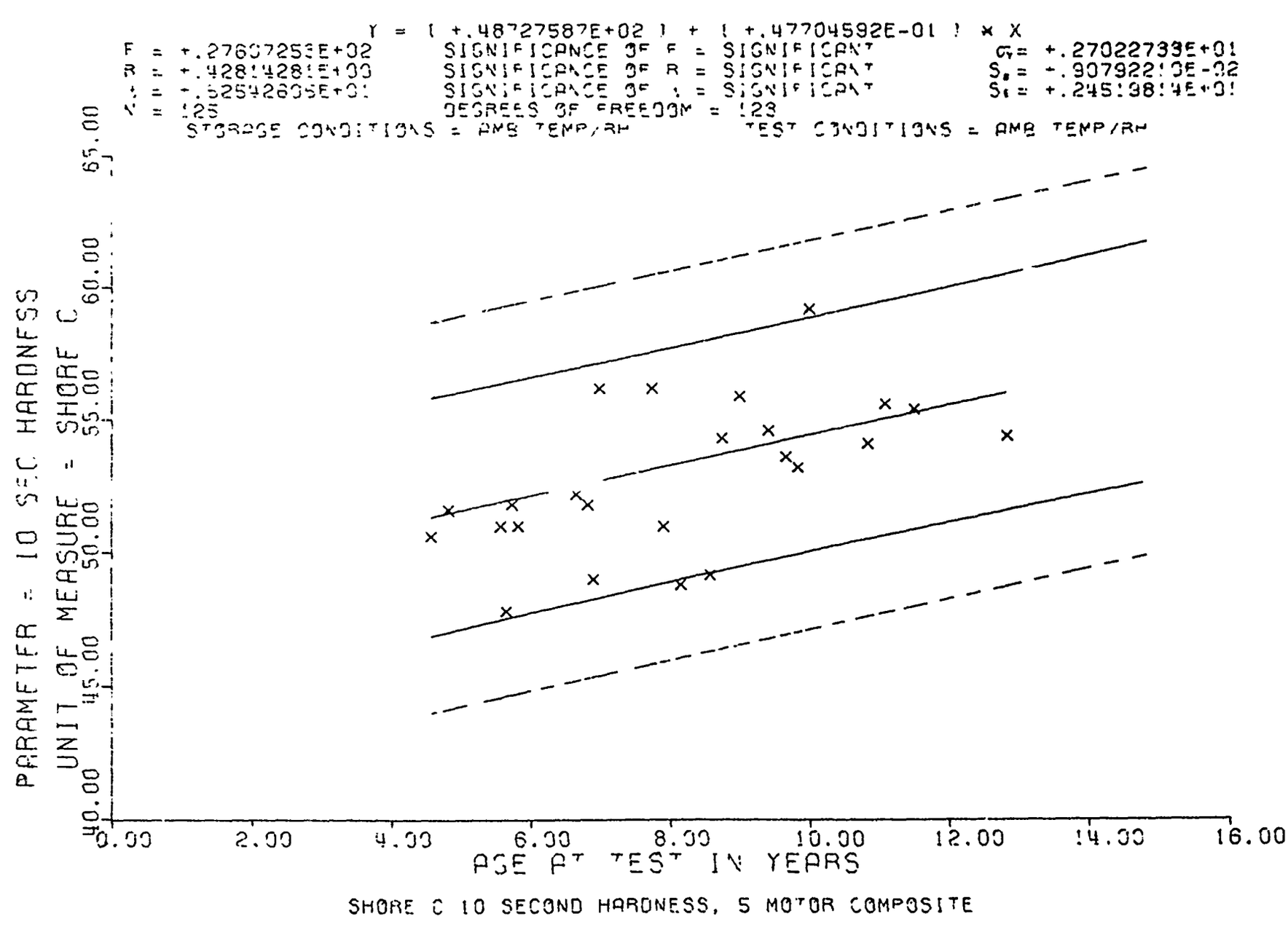

Y = [+.48727587E+02] + [+.47704592E-01] * X
F = +.27607253E+02
R = +.42814281E+00
SIGNIFICANCE OF F = SIGNIFICANT
SIGNIFICANCE OF R = SIGNIFICANT
SIGNIFICANCE OF ; = SIGNIFICANT
DEGREES OF FREEDOM = 123
STORAGE CONDITIONS = AMB TEMP/RH
TEST CONDITIONS = AMB TEMP/RH
PARAMETER = 10 SEC HARDNESS
UNIT OF MEASURE = SHORE C
40.00
45.00
50.00
55.00
60.00
65.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST IN YEARS
SHORE C 10 SECOND HARDNESS, 5 MOTOR COMPOSITE

Figure 10-2

SECTION XI

THERMAL ANALYSIS

Thermo-analytical testing was limited during this test period. The new TGA was not available and testing of TCLE was delayed so long that the data are not comparable to previous data. The Tg of the recent tests is lower and the TCLE after transition is also lower.

A. Heat of Explosion

This test is run on a 5 gram sample in the Parr Adiabatic Calorimeter under 25 atm of nitrogen.

The five motor composite shows a significant increase (Figure 11-1). This change from lowest to highest values represents a spread of less than 2% of the caloric value.

B. Burning Rate

This test is performed on surface-inhibited strands of propellant (.156" x .156" x 5") at 500 psi N_2 in the Strand Burner Test Apparatus.

The five motor composite has not shown a significant change (Figure 11-2).

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR. SAMPLES
(59.05)	15
70.0	1
82.0	3
83.0	5
95.0	7
98.0	5
106.0	1
107.0	8
110.0	2
118.0	5
121.0	1
130.0	3
131.0	2
133.0	3
142.0	1
154.0	3

HEAT OF EXPLOSION, 5 MOTOR COMPOSITE

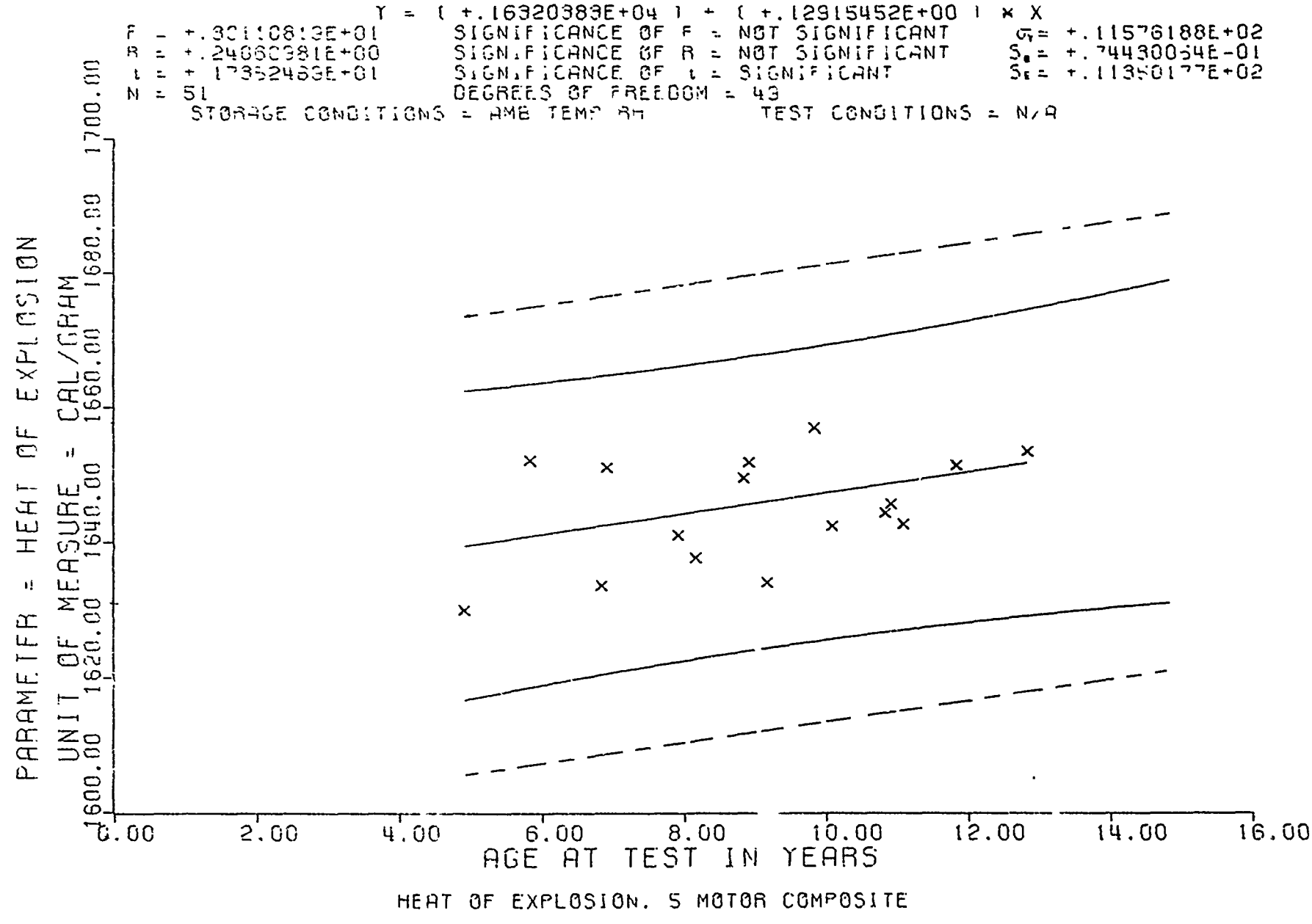
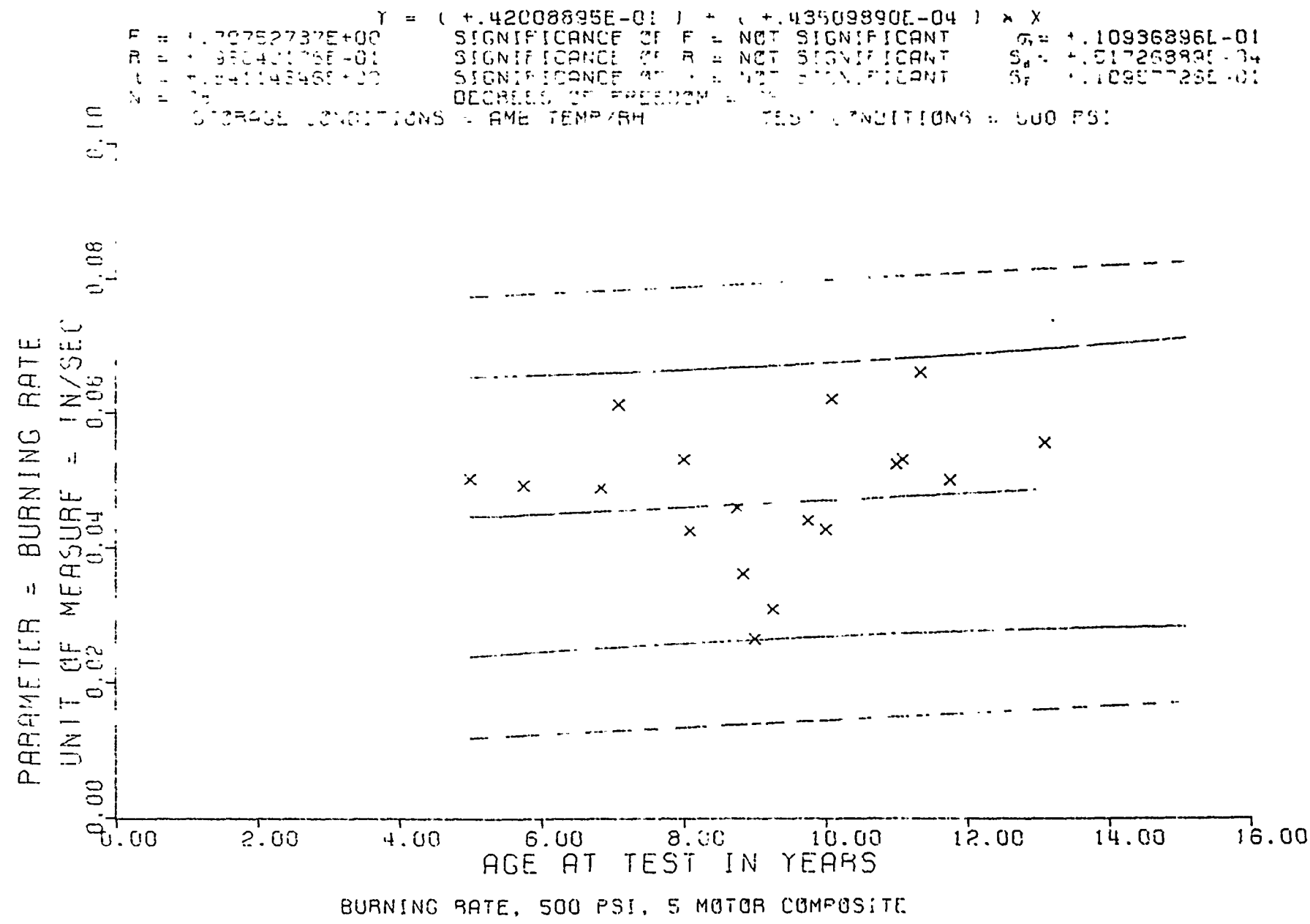

Y = (+.16320383E+04) + (+.12915452E+00) × X
F = +.3011081 3E+01
R = +.2466C381E+00
t = + 1.7352463E+01
N = 51
SIGNIFICANCE OF F = NOT SIGNIFICANT
SIGNIFICANCE OF R = NOT SIGNIFICANT
SIGNIFICANCE OF t = SIGNIFICANT
DEGREES OF FREEDOM = 43
σ = +.11576188E+02
S = +.7443006 4E-01
S = +.1135017 7E+02
STORAGE CONDITIONS = AMB TEMP RH
TEST CONDITIONS = N/A
PARAMETER = HEAT OF EXPLOSION
UNIT OF MEASURE = CAL/GRAM
1600.00
1620.00
1640.00
1660.00
1680.00
1700.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST IN YEARS
HEAT OF EXPLOSION, 5 MOTOR COMPOSITE

Figure 11-1

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
(60.0S)	6S
69.0	3
82.0	6
85.0	3
96.0	6
97.0	6
105.0	3
106.0	6
108.0	6
111.0	6
117.0	3
120.0	3
121.0	3
132.0	6
133.0	3
136.0	3
141.0	3
157.0	3

BURNING RATE, 500 PSI, 5 MOTOR COMPOSITE



BURNING RATE, 500 PSI, 5 MOTOR COMPOSITE

Figure 11-2

SECTION XXII

CASE BONDS

The case-liner bond system has been tested for tensile strength and peel strength.

A. The case bond tensile specimens were tested on the Instron at a crosshead speed of 0.1 in/min. The specimens usually failed cohesively in the propellant with some failures in the embedment grain.

The composite regression shows a significant increase in tensile bond strength (Figure 12-1). Individually the motors show a significant increase (Figures 12-2 thru 12-6) except 0033174 (Figure 12-5).

The 1968 and 1973 data for 0031064 are very close. Both sets of data are lower than for any other years (Figure 12-2). The same is true of 0031134 and 0032434 (Figure 12-3 and 4). Grain 131 has a higher value than in 1968 and, in fact, is greater than for any other test period (Figure 12-6).

B. The case bond peel specimens were tested on the Instron at a crosshead speed of 5 in/min in the 90° peel fixture. Motors 0031064 and 0031134 showed embedment grain to resin failure. Motor 0032434 rubber to resin failure and motor 0033174 showed cohesive failure in embedment grains, resin to grain failure and cohesive failure in resin. One peel strip for Grain 131 showed excellent embedment with cohesive failure in the granules. The other two showed approximately 40% exposure of rubber.

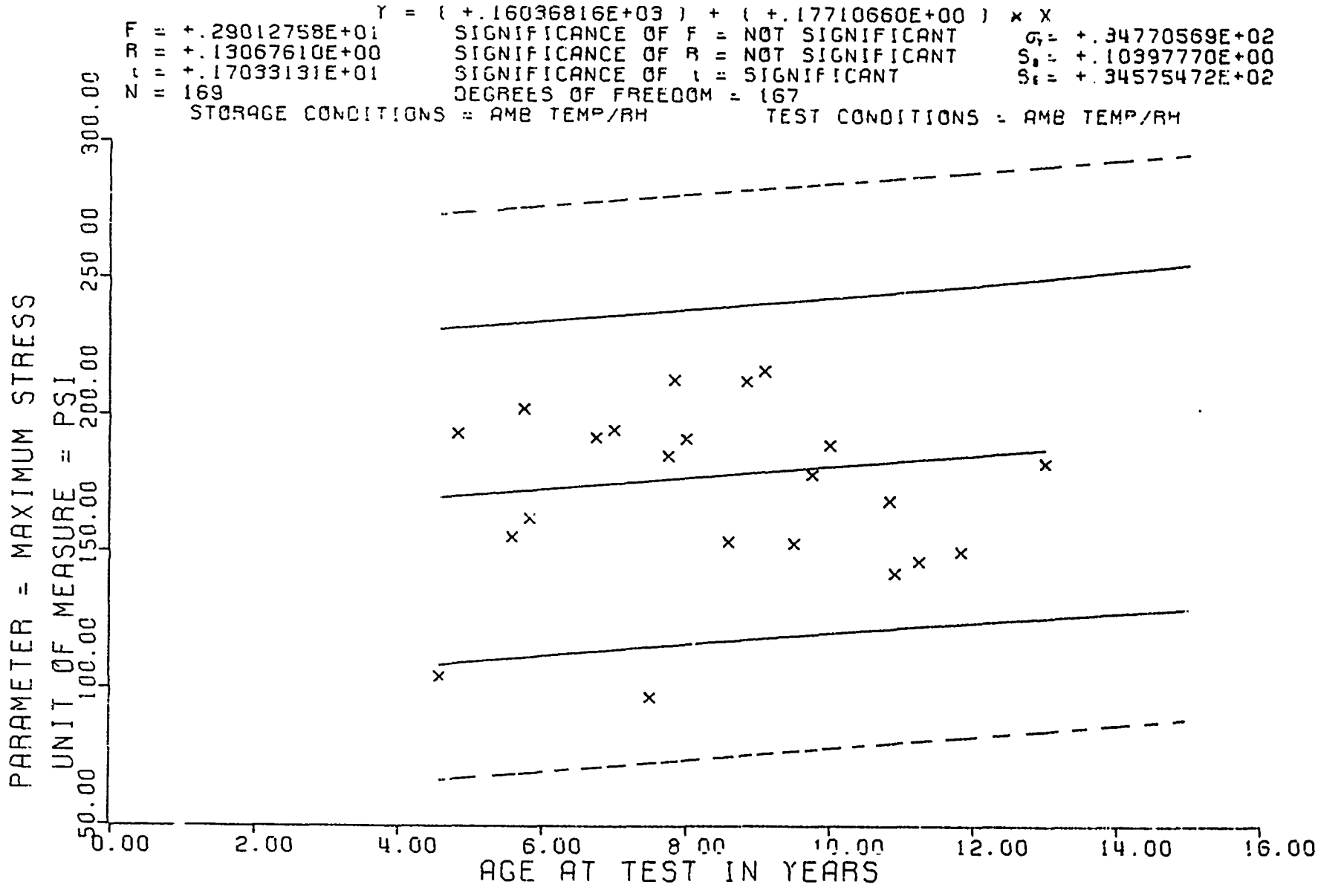
Average peel strength shows a significant decrease for the five motor composite (Figure 12-7). The change in peel strength is not significant for motors 0031064, 0031134 and 0033174 (Figure 12-8, 9 and 11). Motor 0032434 shows a significant decrease (Figure 12-10) and Grain 131 shows a significant increase (Figure 12-12).

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*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
55.0	12
58.0	6
67.0	12
69.0	14
70.0	11
81.0	16
84.0	13
90.0	2
93.0	6
94.0	6
96.0	6
103.0	6
106.0	12
109.0	6
114.0	5
117.0	6
120.0	9
130.0	6
131.0	3
135.0	3
142.0	6
156.0	3

CASE BOND TENSILE MAXIMUM STRESS, CHS 0.1, CSA 1.0, 5 MOTOR COMPOSITE



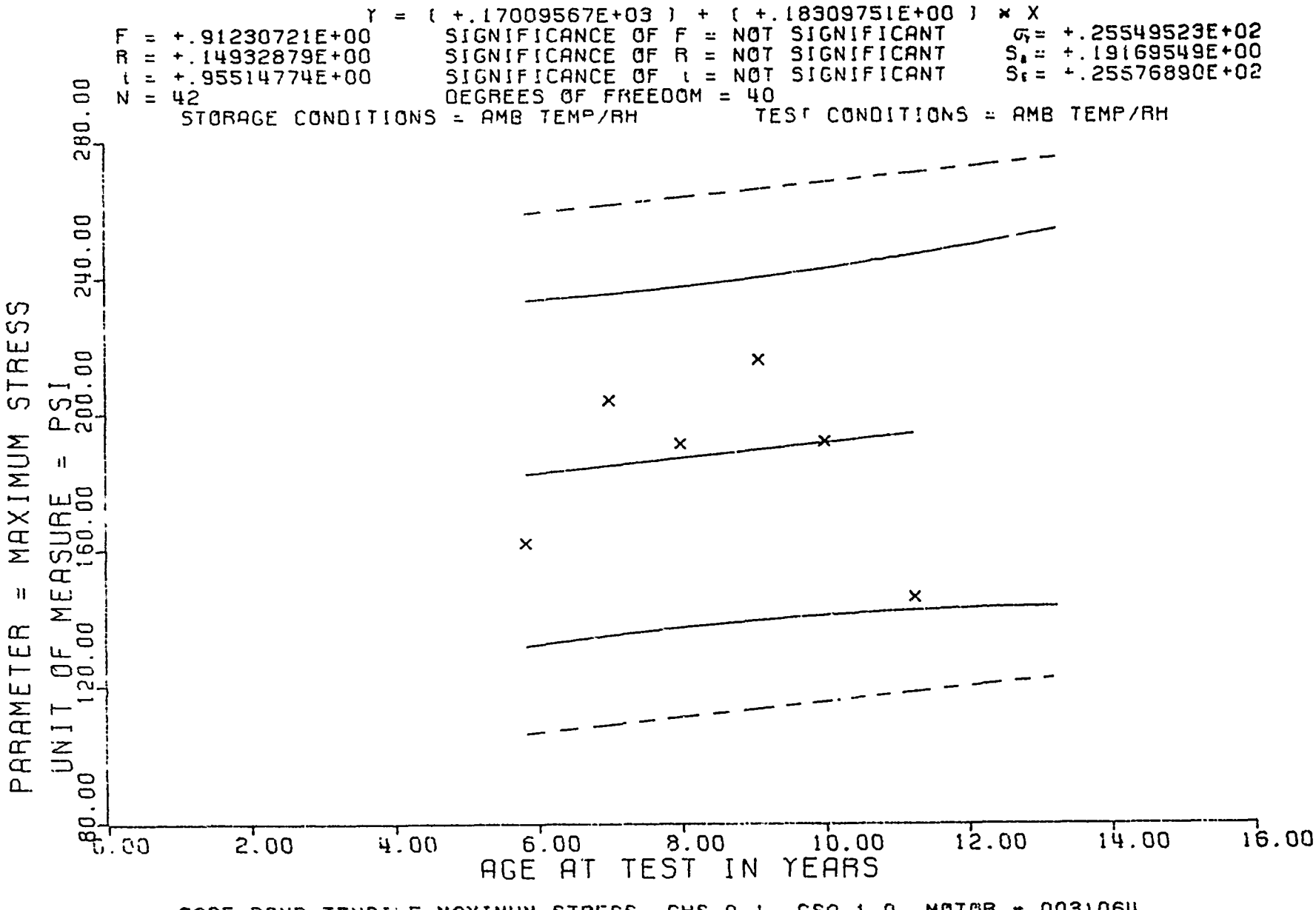
CASE BOND TENSILE MAXIMUM STRESS, CHS 0.1, CSA 1.0, 5 MOTOR COMPOSITE

FIGURE 12-1

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
70.0	11
84.0	10
96.0	6
109.0	6
120.0	6
135.0	3

CASE BOND TENSILE MAXIMUM STRESS, CHS 0.1, CSA 1.0, MOTOR # 0031064



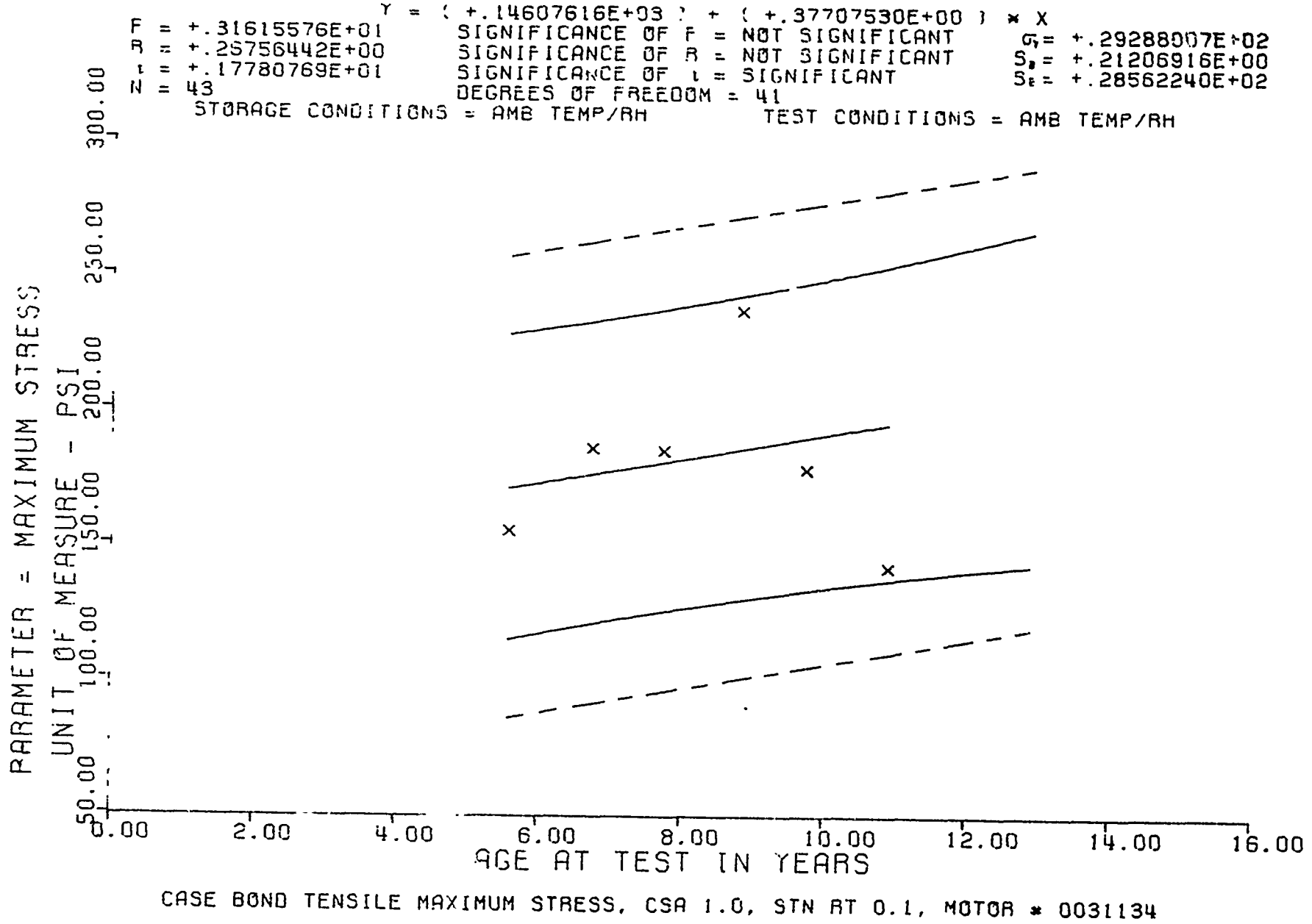
CASE BOND TENSILE MAXIMUM STRESS, CHS 0.1, CSA 1.0, MOTOR # 0031064

FIGURE 12-2

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
(67.05)	12S
81.0	10
93.0	6
106.0	6
117.0	6
131.0	3

CASE BOND TENSILE MAXIMUM STRESS, CSA 1.0, STN RT 0.1, MOTOR # 0031134



CASE BOND TENSILE MAXIMUM STRESS, CSA 1.0, STN RT 0.1, MOTOR * 0031134

FIGURE 12-3

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
(55.05)	125
69.0	10
81.0	6
94.0	6
106.0	6
120.0	3

CASE BOND TENSILE MAXIMUM STRESS, CSA 1.0, STN RT 0.1, MOTOR # 0032434

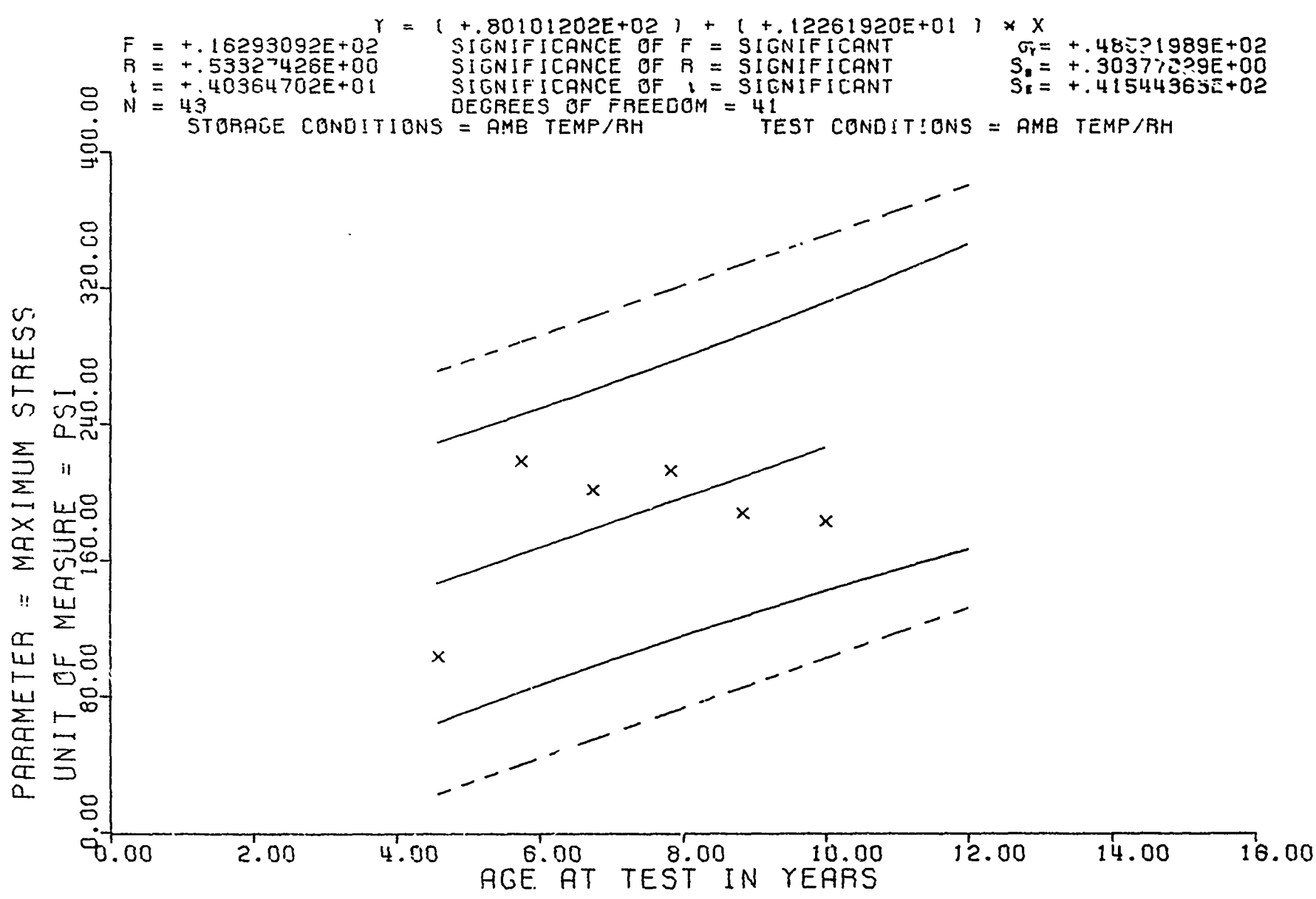
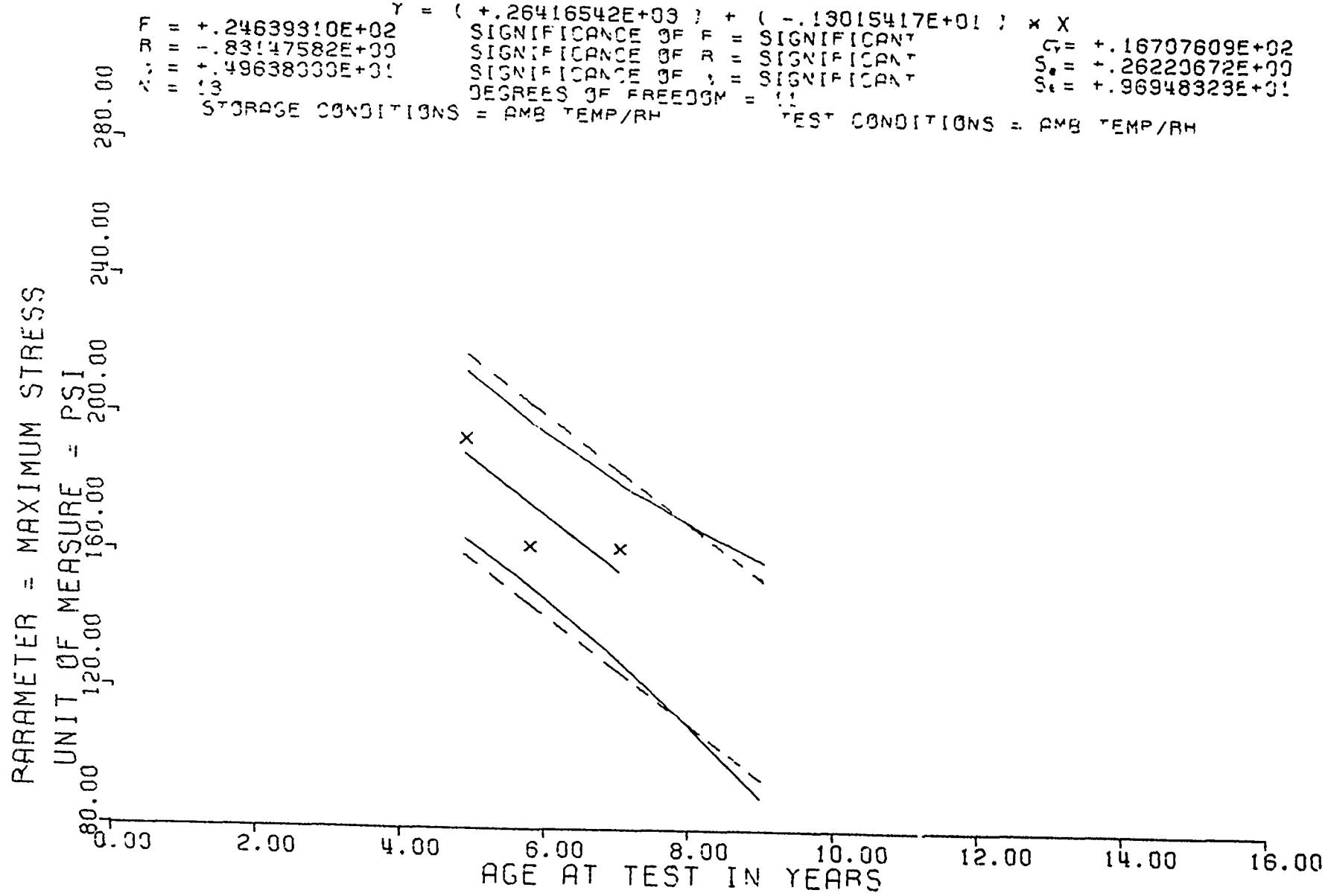

Y = (+.80101202E+02) + (+.12261920E+01) * X
F = +.16293092E+02 SIGNIFICANCE OF F = SIGNIFICANT
R = +.53327426E+00 SIGNIFICANCE OF R = SIGNIFICANT
t = +.40364702E+01 SIGNIFICANCE OF t = SIGNIFICANT
N = 43 DEGREES OF FREEDOM = 41
STORAGE CONDITIONS = AMB TEMP/RH
TEST CONDITIONS = AMB TEMP/RH
PARAMETER = MAXIMUM STRESS
UNIT OF MEASURE = PSI
0.00
80.00
160.00
240.00
320.00
400.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST IN YEARS
CASE BOND TENSILE MAXIMUM STRESS, CSA 1.0, STN RT 0.1, MOTOR * 0032434

FIGURE 12-4

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NO. SAMPLES
58.0	65
69.0	4
84.0	3

CASE BOND TENSILE MAXIMUM STRESS, CSA 1.0, STN RT 0.1, MOTOR # 0033174



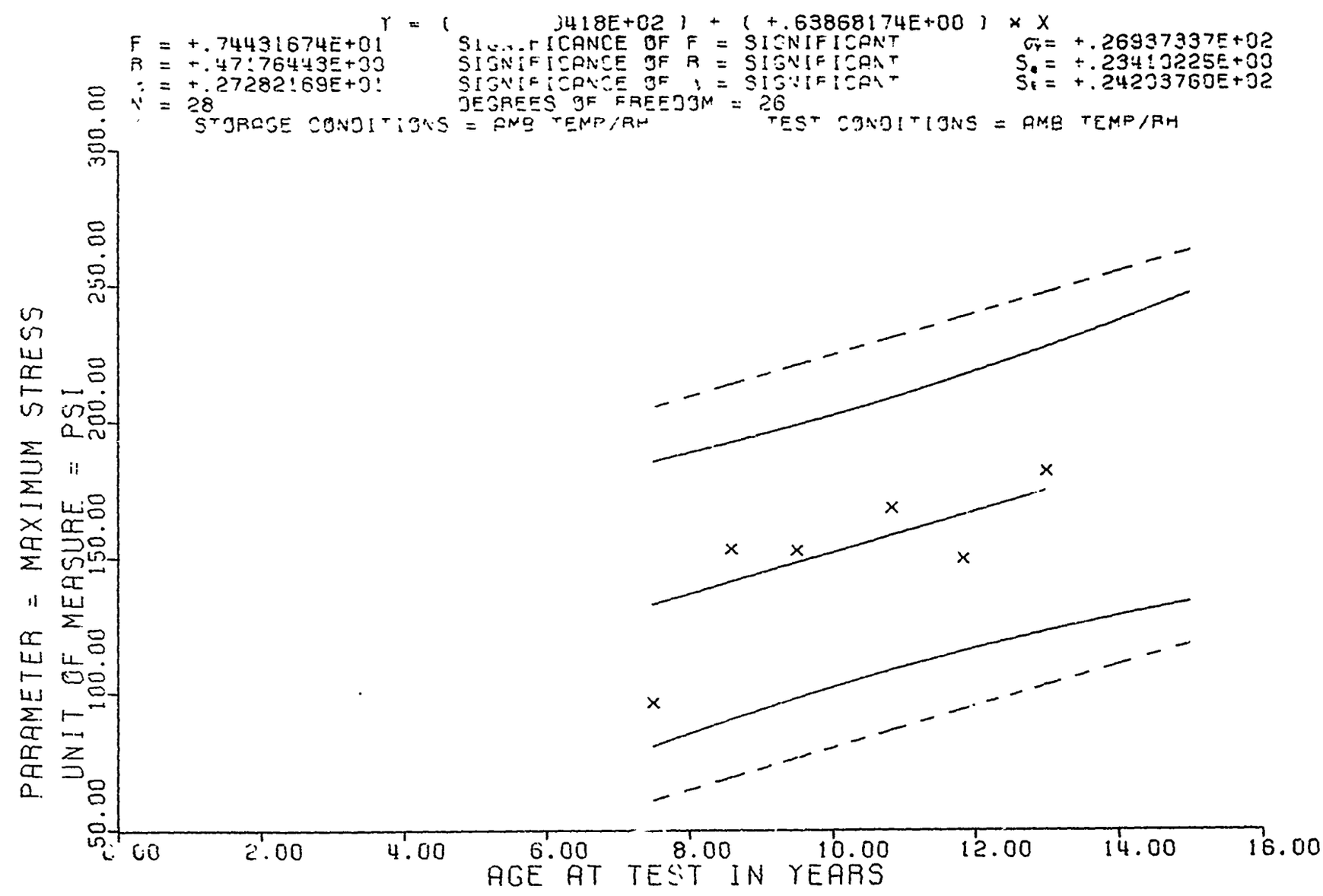
CASE BOND TENSILE MAXIMUM STRESS, CSA 1.0, STN RT 0.1, MOTOR = 0033174

FIGURE 12-5

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
(90.05)	25
103.0	6
114.0	5
130.0	6
142.0	6
156.0	3

CASE BOND TENSILE MAXIMUM STRESS, CSA 1.0, STN RT 0.1, MOTOR # 00GR131



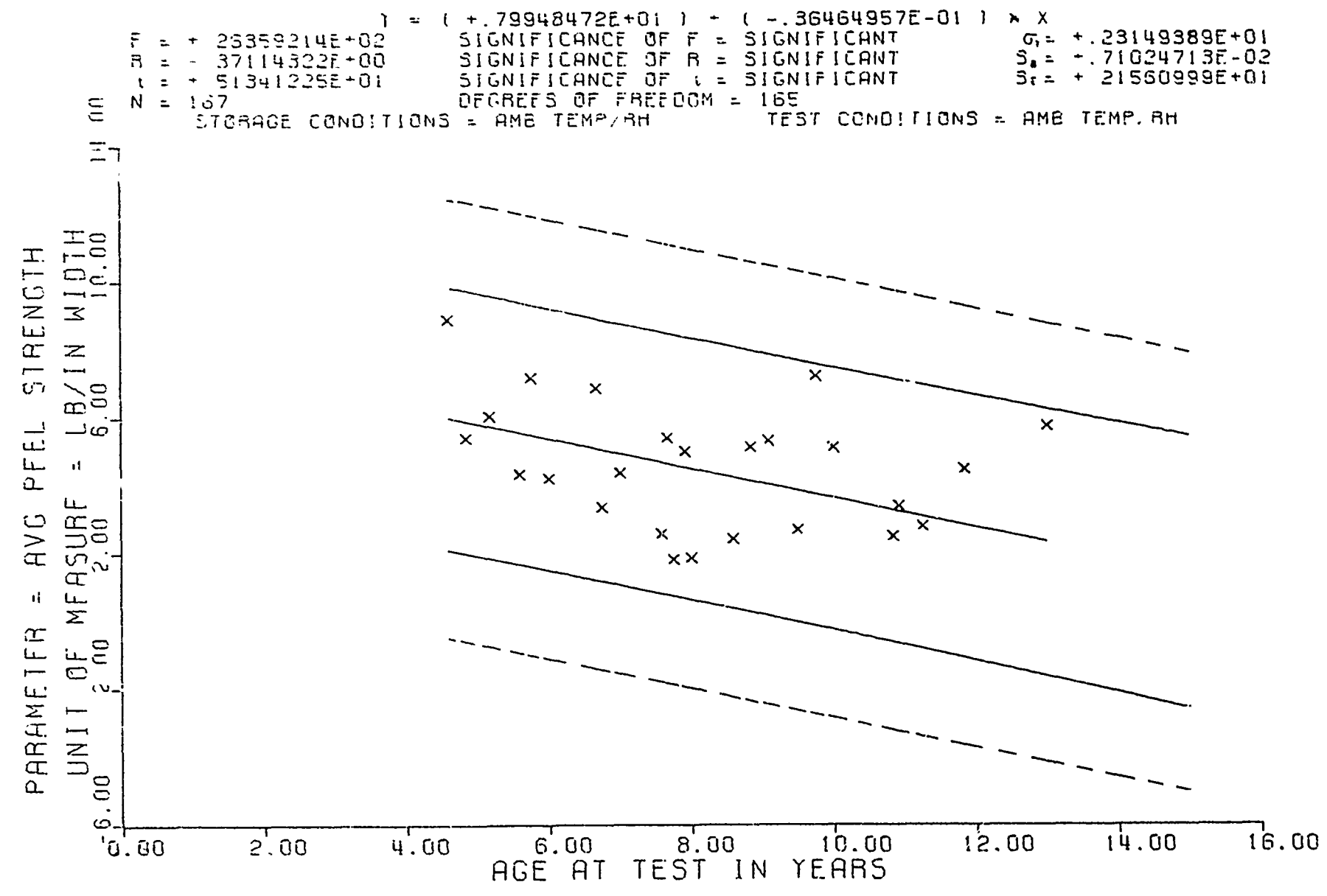
CASE BOND TENSILE MAXIMUM STRESS, CSA 1.0, STN RT 0.1, MOTOR = 00GR131

FIGURE 12-6

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	N= SAMPLES
(55.0S)	12S
58.0	1
62.0	3
67.0	10
69.0	17
72.0	11
80.0	5
81.0	18
84.0	15
91.0	6
92.0	6
93.0	6
95.0	6
96.0	6
103.0	6
106.0	6
109.0	3
114.0	3
117.0	3
120.0	6
130.0	6
131.0	3
135.0	3
142.0	3
156.0	3

AVERAGE CASE BOND PEEL, CHS 5.0 IN/MIN, 5 MOTOR COMPOSITE



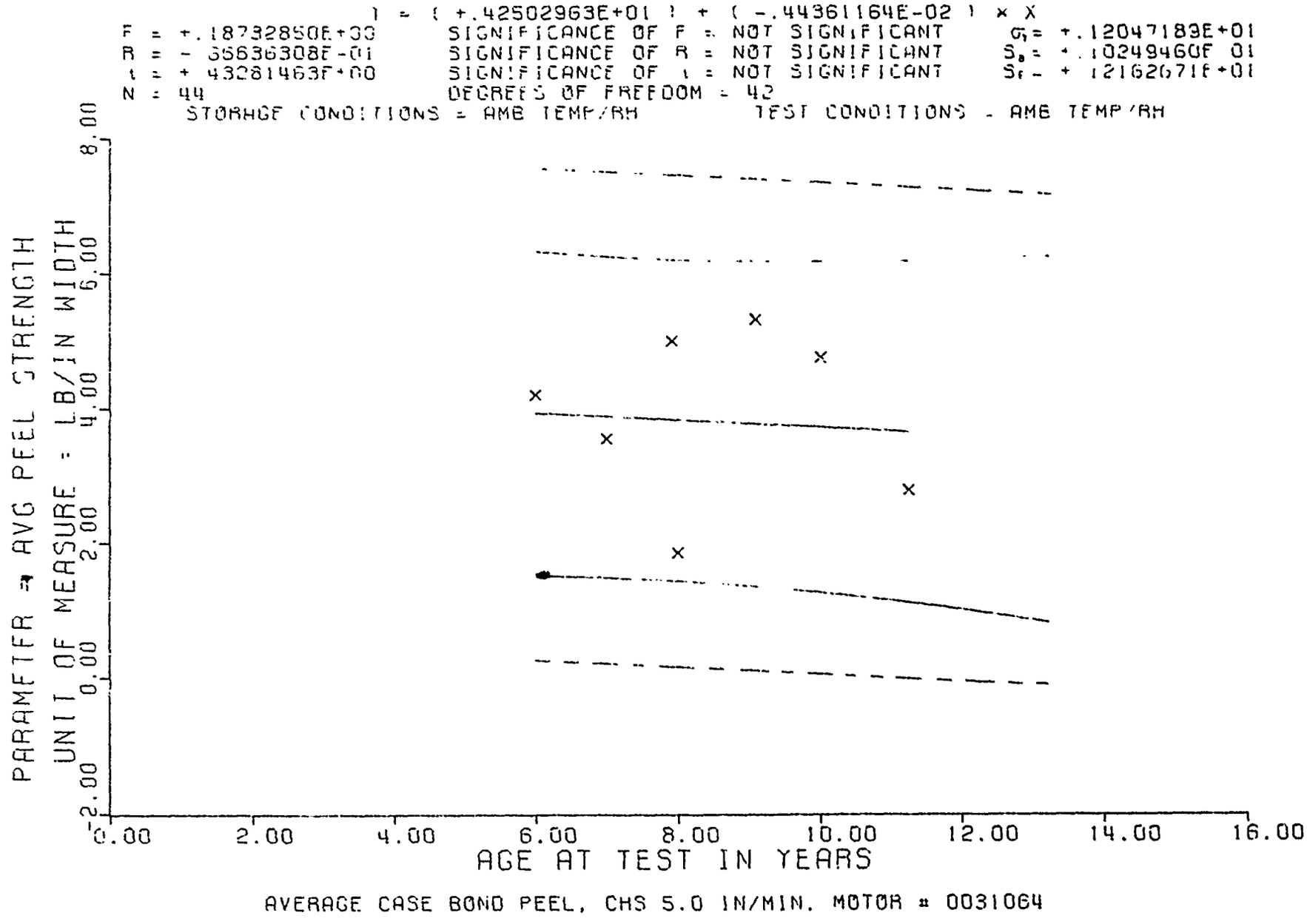
AVERAGE CASE BOND PEEL, CHS 5.0 IN/MIN. 5 MOTOR COMPOSITE

FIGURE 12-7

*** SAMPLE SIZE SUMMARY ***

[illegible] (MONTHS)	No. SAMPLES
(72.0)	11
84.0	12
96.0	6
96.0	6
109.0	3
120.0	3
135.0	3

AVERAGE CASE BOND PEEL, CHS 5.0 IN/MIN, MOTOR # 0031064



AVERAGE CASE BOND PEEL, CHS 5.0 IN/MIN. MOTOR = 0031064

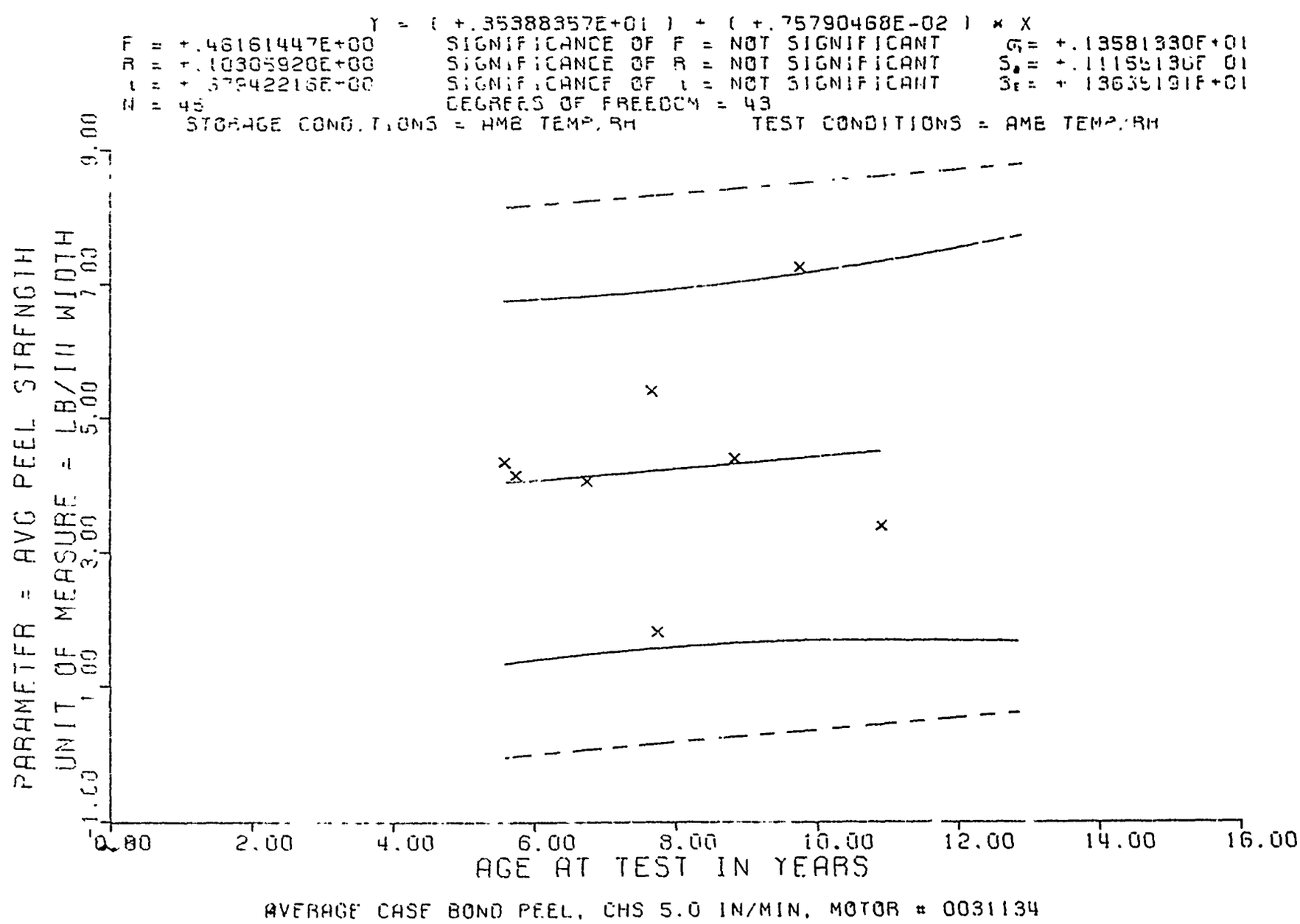
FIGURE 12-8

*** SAMPLE SIZE SUMMARY ***

A,F (CNTRS)	NS SAMPLES
(7.05)	105
89.0	2
91.0	12
92.0	8
93.0	6
106.0	3
117.0	3
131.0	3

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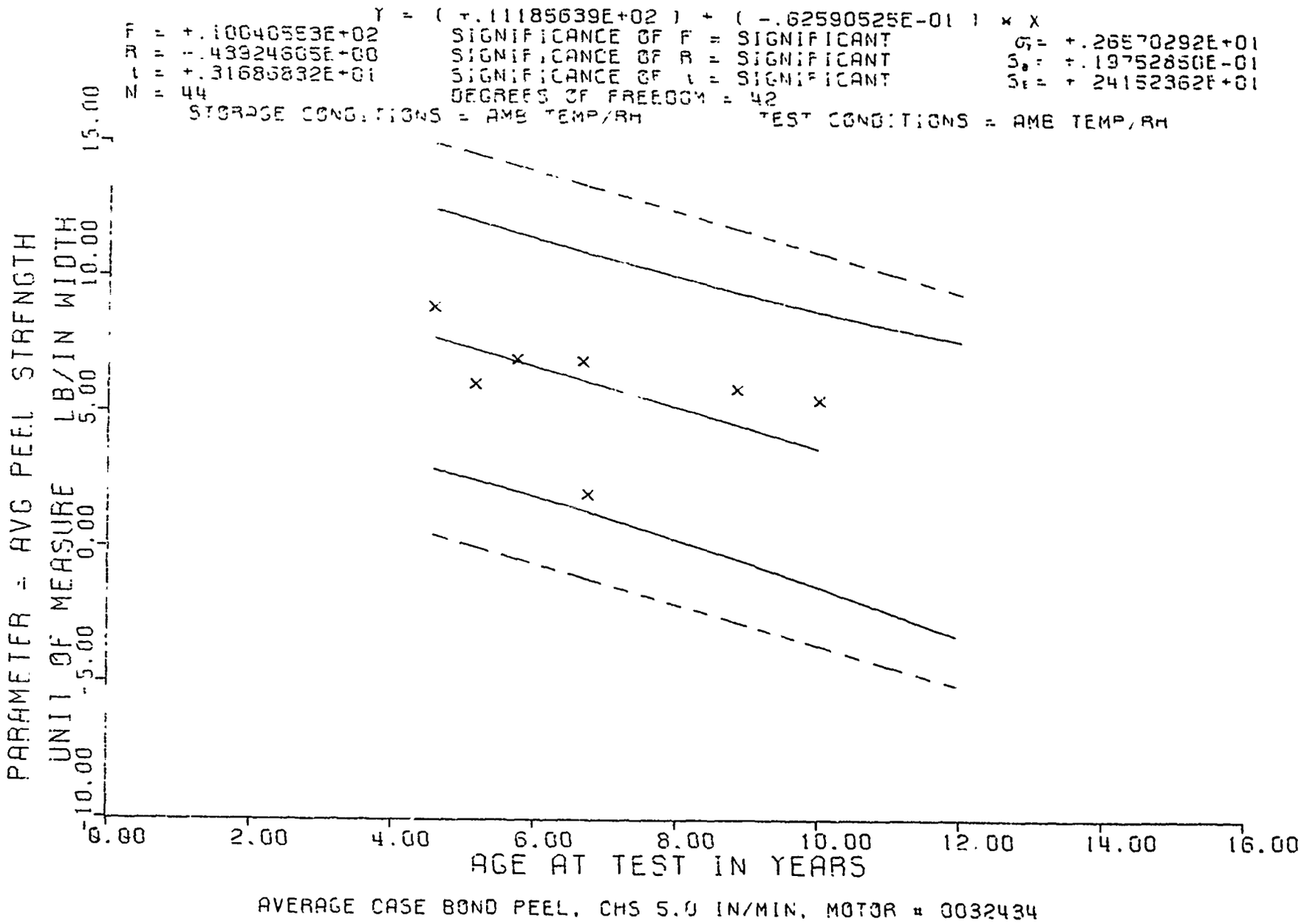
AVERAGE CASE BOND BELL, CHS 5.0 IN/MIN, MOTOR # C031134



AVERAGE CASE BOND PEEL, CHS 5.0 IN/MIN, MOTOR # 0031134

FIGURE 12-9

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AVERAGE CASE BOND PEEL, CHS 5.0 IN/MIN, MOTOR = 0032434

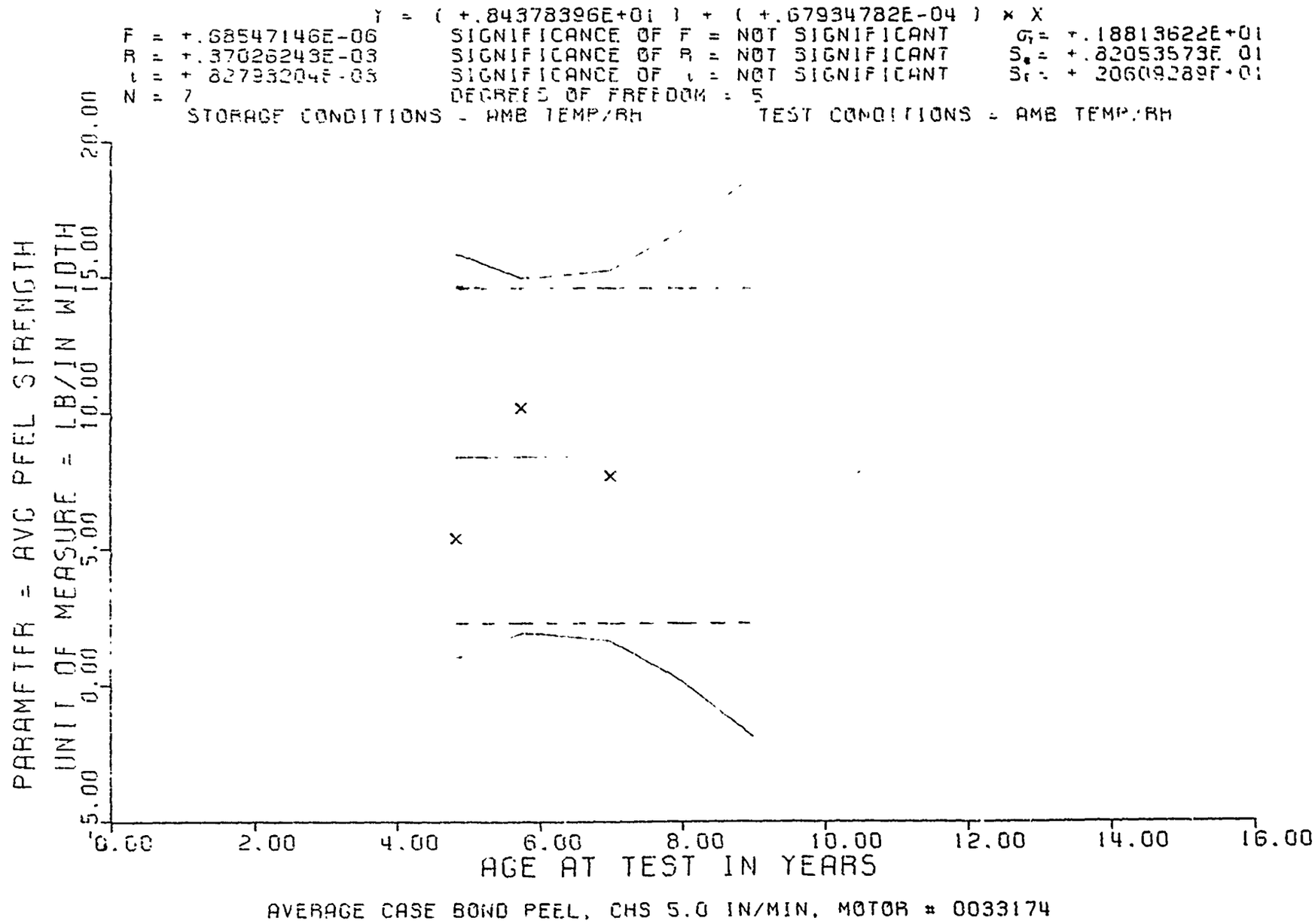
FIGURE 12-10

Reproduced from best available copy.

*** SAMPLE SIZE SUMMARY ***

AGE (CENTS)	NO. SAMPLES
(99.0)	15
95.0	3
94.0	2

AVERAGE CASE : ONE PEEL, CHS 5.0" ID/4.0", VOTES # 0032174



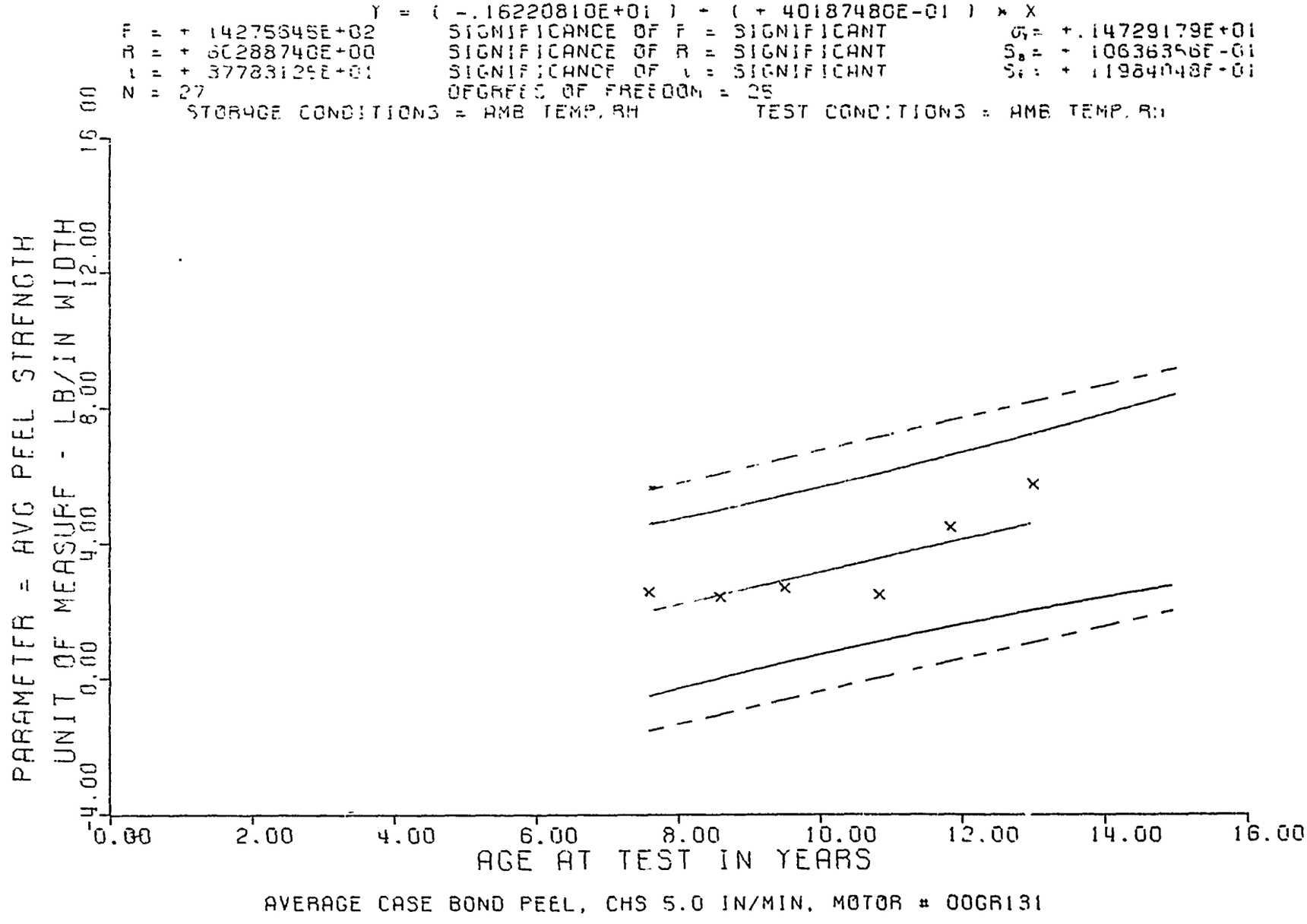
AVERAGE CASE BOND PEEL, CHS 5.0 IN/MIN, MOTOR # 0033174

FIGURE 12-11

*** SAMPLE SIZE SUMMARY ***

X (UNITS)	N= SAMPLES
(91.55)	44
138.	6
114.	3
136.0	5
142.0	3
196.0	2

AVERAGE CASE BOND PEEL, CPS 5.0 IN/MIN, MoTo. * 00GF131



AVERAGE CASE BOND PEEL, CHS 5.0 IN/MIN, MOTOR # 00GR131

FIGURE 12-12

SECTION XIII

DYNAMIC RESPONSE

This test uses a Gottenberg disc 3.3" in diameter with a 125 gm center weight. An Unholtz-Dickie apparatus is used and the specimen tested at 0.5 g through a range of frequencies. Reduced data from 200 and 600 Hz are shown in regression.

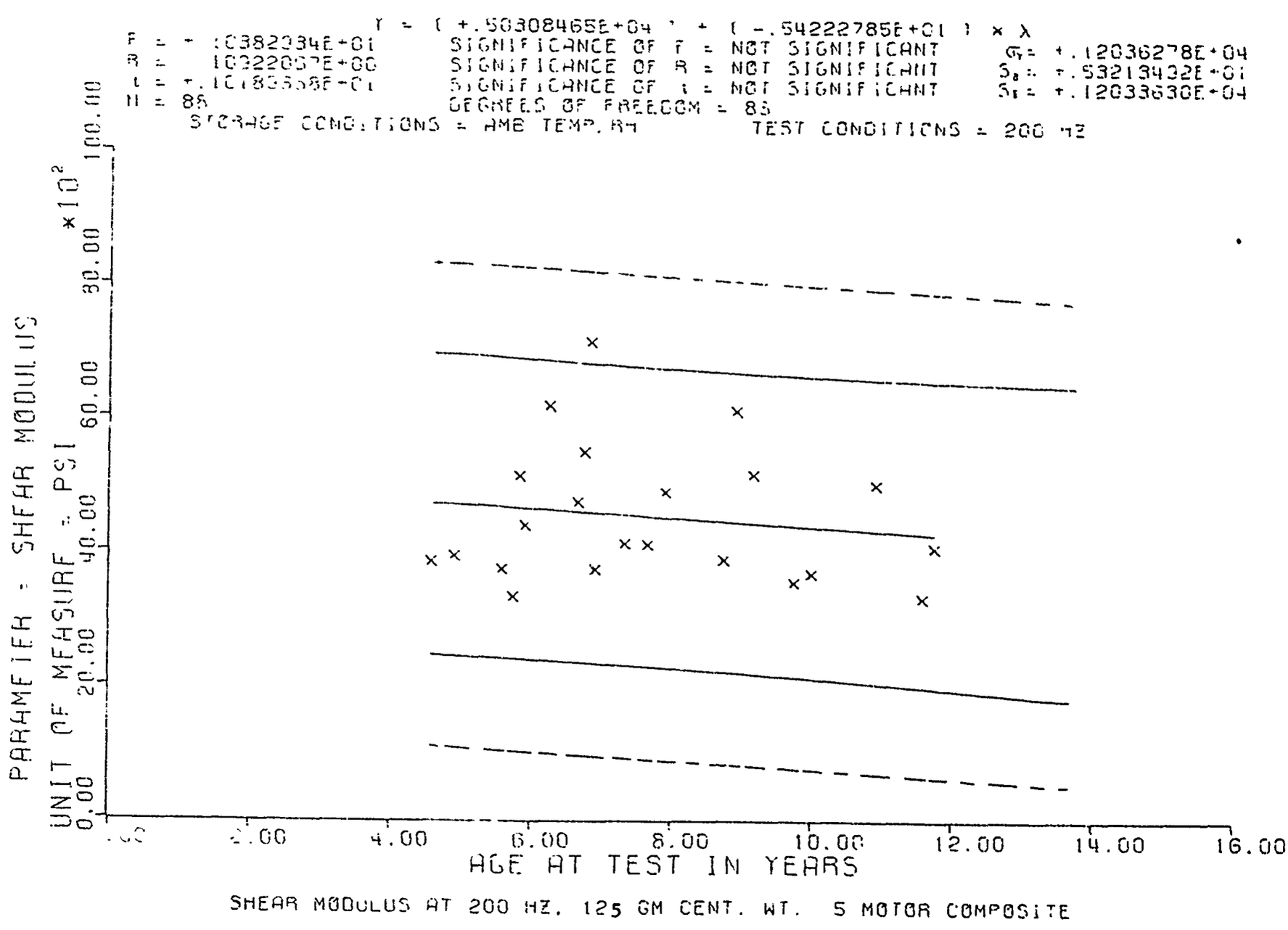
Storage shear modulus at 200 Hz does not show a significant change (Figure 13-1). At 600 Hz there is a significant decrease (Figure 13-2).

Loss tangent increases significantly at 200 and 600 Hz (Figure 13-3 and 13-4).

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NO. SAMPLES
(55.05)	55
59.0	3
67.0	5
69.0	3
70.0	6
71.0	1
75.0	3
80.0	3
81.0	6
82.0	3
83.0	6
88.0	1
92.0	6
95.0	9
105.0	3
107.0	3
110.0	3
117.0	3
120.0	3
131.0	3
139.0	5
141.0	3

SHEAR MODULUS AT 200 HZ. 124 GM CENT. WT.. 5 MOTOR COMPOSITE



SHEAR MODULUS AT 200 HZ, 125 GM CENT. WT. 5 MOTOR COMPOSITE

FIGURE 13-1

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NK SAMPLES
(55.05)	55
59.0	3
67.0	5
69.0	3
70.0	8
71.0	1
75.0	3
80.0	3
81.0	6
82.0	3
83.0	6
88.0	1
92.0	6
95.0	9
105.0	3
107.0	3
110.0	3
117.0	3
120.0	3
131.0	3
139.0	5
141.0	3

LOSS TANGENT AT 200 HZ. 124 GM CENT. WT., 5 MOTOR COMPOSITE

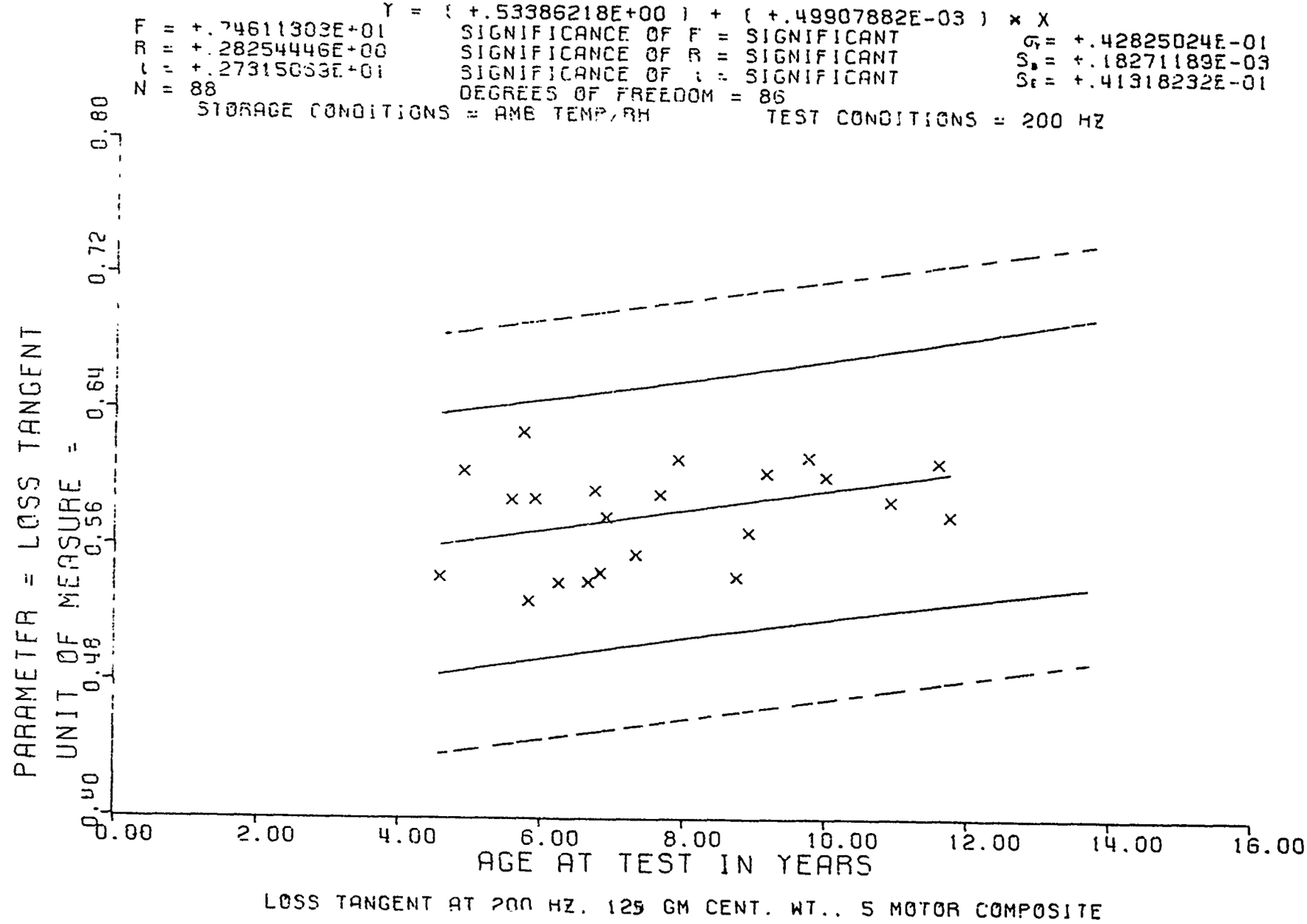
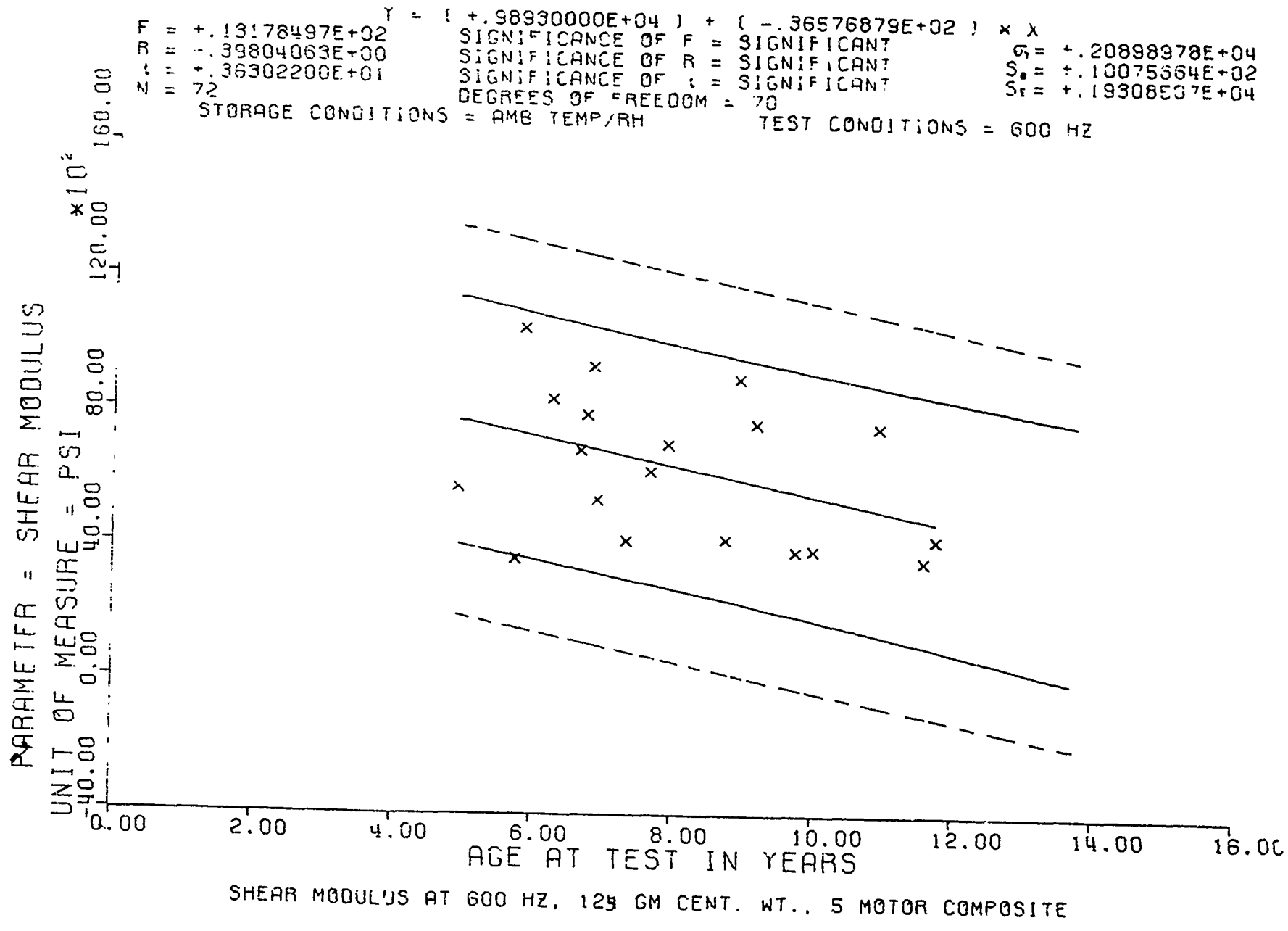

Y = (+.53386218E+00) + (+.49907882E-03) * X
F = +.74611303E+01
SIGNIFICANCE OF F = SIGNIFICANT
σr = +.42825024E-01
R = +.28254446E+00
SIGNIFICANCE OF R = SIGNIFICANT
Sb = +.18271189E-03
t = +.27315033E+01
SIGNIFICANCE OF t = SIGNIFICANT
Sε = +.41318232E-01
N = 88
DEGREES OF FREEDOM = 86
STORAGE CONDITIONS = AMB TEMP/RH
TEST CONDITIONS = 200 HZ
PARAMETER = LOSS TANGENT
UNIT OF MEASURE =
0.40
0.48
0.56
0.64
0.72
0.80
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
AGE AT TEST IN YEARS
LOSS TANGENT AT 200 HZ. 125 GM CENT. WT.. 5 MOTOR COMPOSITE

FIGURE 13-2

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
(-59.95)	35
65.0	3
70.0	3
75.0	3
80.0	3
81.0	6
82.0	3
83.0	6
88.0	1
92.0	6
95.0	9
105.0	3
107.0	3
110.0	3
117.0	3
120.0	3
131.0	3
139.0	5
141.0	3

SHEAR MODULUS AT 600 HZ. 124 GM CENT. WT., 5 MOTOR COMPOSITE



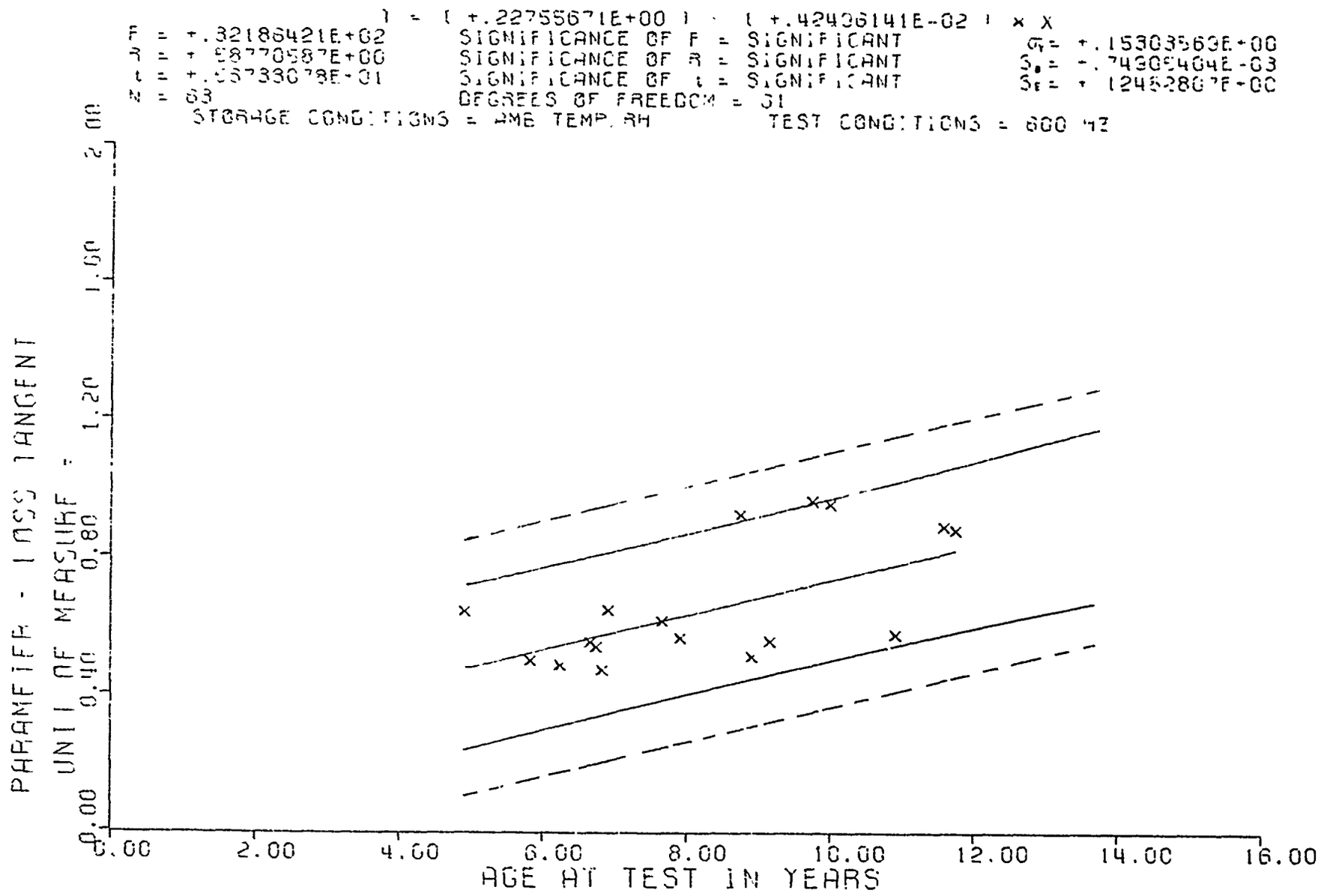
SHEAR MODULUS AT 600 HZ, 125 GM CENT. WT., 5 MOTOR COMPOSITE

FIGURE 13-3

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
(-59.0S)	35
70.0	3
75.0	3
80.0	3
81.0	6
82.0	3
83.0	6
92.0	6
95.0	9
105.0	3
107.0	3
110.0	3
117.0	2
120.0	2
131.0	3
139.0	3
141.0	2

LOSS TANGENT AT 600 HZ, 124 GM CENT. WT., 5 MOTOR COMPOSITE



LOSS TANGENT AT 600 HZ, 125 GM CENT. WT., 5 MOTOR COMPOSITE

FIGURE 13-4